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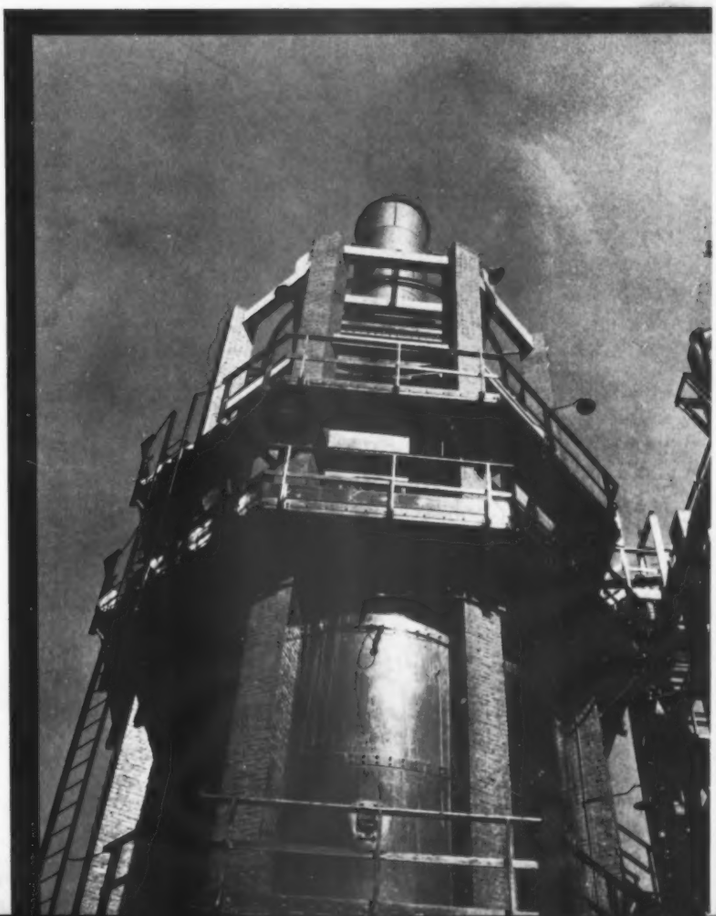

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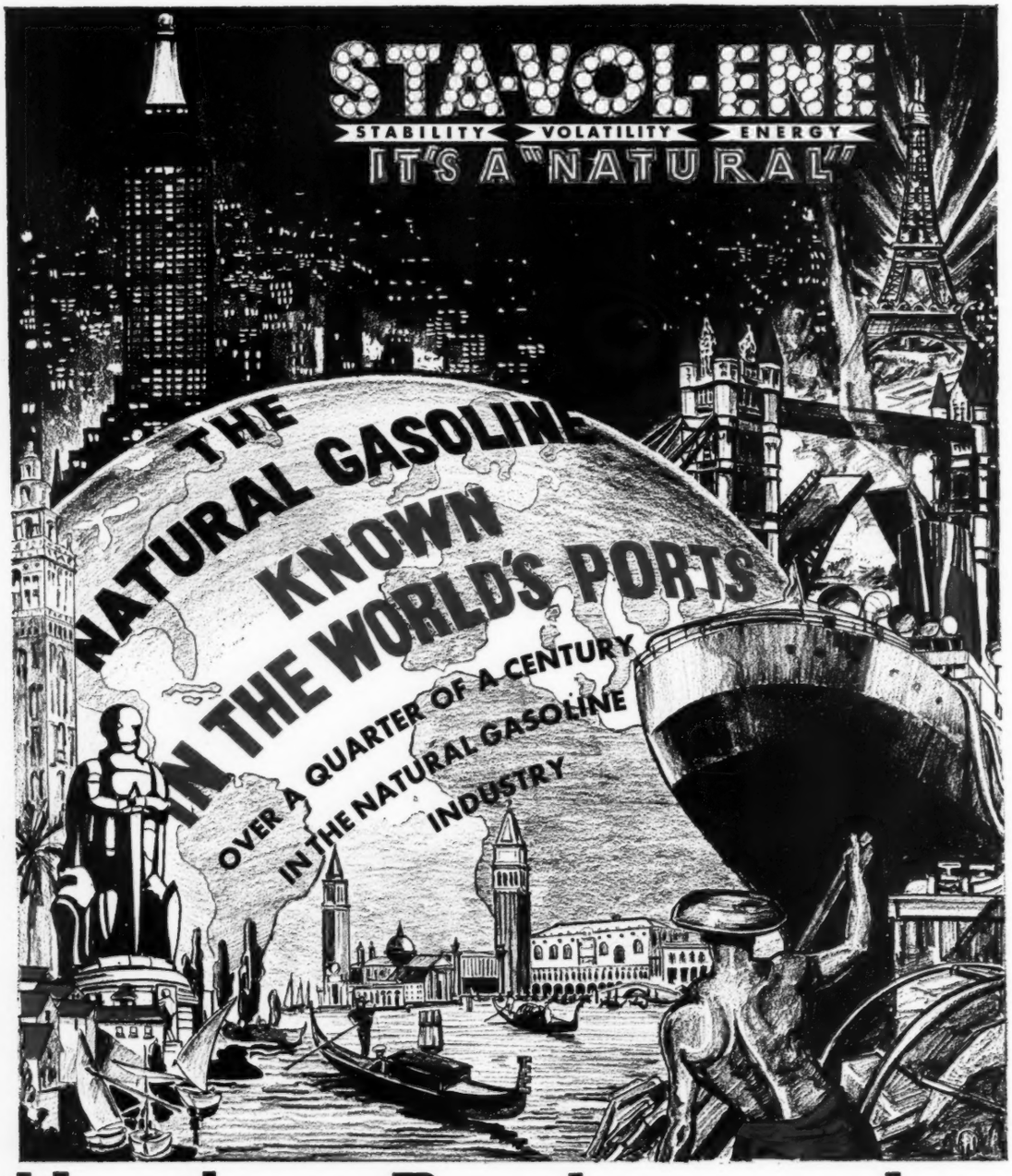
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PETROLEUM

Refineries Large and Small

PROGRESS in the expansion of the world's refining facilities has continued at unabated pace during the past year. Two differing but not opposing trends are noticeable. Additions of new units to existing plants have led to the creation of establishments far exceeding in daily capacity anything dreamed of five or ten years ago. At the same time the number of small plants has increased so that the ratio between the two has not changed materially.

Predictions have been made frequently during the past few years that small refineries would be driven out of existence by the growth of large competitors handling 50,000 to 100,000 or even 200,000 bbl. of crude daily, but there is nothing to support this view in the record of current activities. It would be more correct to say that the growth of each class reflects the state of integration in different localities or different sections of the industry. As large companies have expanded the volume of their crude supplies they have built larger and larger plants, mostly near their sources of supply, to handle this output.

In other places, where crude outturn is in the hands of a number of small producers or where the opportunity exists to serve a local or limited market, smaller refineries continue to hold their own and to show a healthy growth in numbers from year to year. While there are certain economies in the handling of oil, or almost any other commodity, in large quantities, it has yet to be proved that mass production, beyond a certain point, can offset the advantages of a compact organization serving nearby markets. In other words the economic position of the smaller plant, provided it is efficiently equipped and managed, may be just as strong as that of one, two or three times its size.

One tendency that is noteworthy in the case of refineries of small capacity is the spread of cracking. Development of cracking equipment adapted to the needs of plants of less than average capacity, and within their means, is an important step in the progress of the past few years and one that puts the smaller refineries on a virtual equality with those of larger size. Statistics show that cracking facilities are now installed in a great majority of all active refineries. While the antiquated skimming plant may persist for a time here and there, its days as a factor of consequence in the industry are clearly numbered.

One of the most widely discussed present day refining trends is the extent of the applicability of the polymerization process to produce an addition agent capable of blending to produce premium grade motor fuels.

Utilization of Research

IN THE field of research and in the adaptation of petroleum to meeting new and exacting demands the year has been notable for the advancement made in the production of higher test gasolines and the announcement of motor fuels above one hundred octane rating. Several installations for the production of such high grade fuel have been made during the past twelve months.

A year ago polymerization was a new factor in the industry and the first plants were just approaching completion. Today its possibilities and limitations are better understood and a number of new plants have been put into commission.

Lubricating oils likewise have been brought up to the point of withstanding heavier pressures. Special attention has been paid to meeting successfully the requirements of automotive engineers for a lubricant equal to the demands put upon it by the use of hypoid gears. Solvent refining and dewaxing methods have come in for a great amount of attention as evidenced by the number of new installations devoted to each of these processes.

Research engineers and chemists are continually discovering new physical and chemical properties and possibilities of petroleum. The more they learn about its structure, the more completely they succeed in taking it apart and studying its constituents, the greater do they find the potentialities of enlarging its sphere of usefulness and thereby simplifying the world's work. While the products and by-products of oil already are numbered in the hundreds, additions are constantly being made to the list, many of them of present or future industrial importance. In the utilization of refinery gases, to mention a single instance, it has been found that former wastes are capable of making valuable contributions to plant products.

Of more immediate importance to the average person than the new and startling discoveries in the field of research is the fact that motor fuels and oils are steadily being improved in quality and performance, as they have been each year for many years past. The average non-premium products now being offered to the public are superior to the best that could be turned out in the best equipped plants only a few years ago. Not only that but they are lower in cost and, despite the fresh layers of taxation that are being put upon them from season to season, are giving consumers greater value for their expenditure, thereby contributing to the enjoyment and usefulness resulting from the employment of modern engines.

Complaint sometimes is voiced that the progress made in methods and equipment in the oil industry is so rapid that

costly plants become obsolete almost as soon as they are completed. It is true that the rate of obsolescence in this industry is higher than in almost any other, but this, in reality, is an element of great strength rather than of weakness. The very fact that more efficient and economical methods and equipment are constantly being developed enables the progressive refiner to hold his lead in competition and to set a pace of improvement that keeps the whole industry moving forward. The many millions of dollars expended each year on new structures are not wasted, but are paid for by gains shared equally between producers and consumers.

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Compact Faces Test

UNEXPECTED strain put upon the interstate compact among leading oil producing states in the United States and the threat that the compact might break down has engrossed the attention of American oil producers during the past few weeks. The crisis, if such it may be termed, was precipitated by the action of the Texas Railroad Commission in setting the allowable crude production of the state so far above the estimate of requirements published by the United States Bureau of Mines as to constitute what seemed to other members a menace to the stability of the crude price situation.

Oklahoma authorities countered their neighbor's action by letting it be known that they contemplated a similar increase. Such a course by the two largest producers undoubtedly would lead to the lifting of limitations in other areas with every probability of at least a temporary collapse in crude prices.

While the situation still presents possibilities of mischief as this is written the chances strongly favor such modification by the Texas Commission of its course as will avoid retaliatory measures by other states. No state official wants to take the responsibility for causing a break in the crude price structure which clearly is safe for the balance of the year or longer unless some assault of deliberate violence is made upon it. It requires no great political foresight on the part of such an official to realize that such a course would bring a flood of protests from producers in his own particular territory.

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Strength of Agreement

SEIZING upon these occurrences as a proof that interstate action was insufficient to hold production in line with current demand the advocates of federal regulation immediately began to point a moral to adorn the tale. Secretary of the Interior Ickes, indefatigable champion of governmental control of the oil industry, was quoted as saying:

"Of course if the states begin to do that (disregard Bureau of Mines estimates) the whole thing will break down all along the line and we will have excess production and lower prices. . . . I've never believed in the compact idea. You cannot operate under it. California, one of the three largest producers, is not in on the compact. I endorse what Gov. Landon said, it is the deadest of all dead horses."

Whether Gov. Landon ever referred to the interstate agreement as a dead horse we do not know, but if the incident should be terminated by a reduction of the Texas allowable it would seem to illustrate nicely the real basis of strength on which the compact rests. If one member takes an unreasonable stand in regard to output the others have an effective weapon to use against him since no office holder who values his political life will want to shoulder open responsibility for a price debacle.

The interstate compact is not a perfect instrument of proration, but it embodies principles of democratic control on which American oil producers seem to set some store and we feel quite certain that they are not yet ready to abandon it in favor of bureaucratic direction from Washington.

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Strengthening Situation

AS A MATTER of fact the degree of control—or lack of control according to the views of strict regulationists—that has been in effect since the NRA, and with it the federal oil administration, was cast into the discard by the United States Supreme Court, has worked more satisfactorily than most members of the American petroleum industry anticipated. During this period the interstate compact has been the one unifying force in existence and it must be assigned some measure of credit if only as a meeting ground on which state officials could exchange views.

There have been times when it seemed that the situation at one point or another might get out of the control of local producers or local authorities and that a break in crude prices might occur. These difficulties have been surmounted and in no case have been more than a temporary threat.

Thus far in the current year there has been an actual strengthening of the crude position. While state allowables in those states where official proration prevails have been somewhat higher than the advance estimates of demand published by the Bureau of Mines, the latter, properly enough, have held to the conservative side, and the difference has been readily absorbed by the growth of motor fuel consumption which has been greater than was anticipated and has continued in full force further into the fall months than formerly was the case.

At the end of September stocks of domestic and imported crude in the United States were 294,349,000 bbl. as compared with 304,595,000 bbl. a year earlier. Stocks of finished and unfinished gasoline were 57,610,000 bbl. in comparison with 53,376,000 bbl. at the corresponding date in 1935. Adopting the sounder yardstick of measurement on the basis of current demand, stocks of motor fuel at the end of September last year represented approximately 50 days supply while this year they represented only about 48 days supply. It should be noted that crude oil stocks now equal only about 90 days supply: petroleum economists agree that crude oil stocks should not be allowed to go below this figure. It may therefore be assumed that there has been no overproduction of crude oil despite the lack of federal control. While stocks of motor fuel might safely be reduced to a still lower figure there certainly has been no worsening of the supply situation, even without the controlling hand of Washington to direct the industry.

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Synthetic Fuel in Germany

GERMANY'S declaration of intention to become entirely independent of outside supplies of motor fuel within the next three years points to an intensification of efforts that have been under way in the recent past. It is evident that if Germany is to eliminate outside purchases of all petroleum products, or of motor fuels, it can be done only by developing production from sources other than crude oil, and mainly from coal, lignite, gas and coke. Substantial progress has been made along these lines and further expansion in all of them is planned.

Soviet Commission Gives Impressions of U. S.

Punctuality in Answering Mail Plus the Traditional Daily Shave, as Well as Technical Advances in Petroleum Production and Drilling Methods Impress M. Barinov of Glavneft.

THE following interview was taken from ZA INDUSTRIALIZATION for July 30, leading Soviet paper. The interview was apparently designed for home consumption, to give a cheering if not too accurate picture to the workers. American oil men who watched the progress of the Barinov party on its junket through the United States may smile at the criticism of the American oil industry and its methods, since a number of observers formed the impression that many of the party were more interested in the night life and the beauties of Hollywood than in the technical aspects of the American petroleum industry from which Russia has copied so much and learned so little.

EARLY in March we left for the United States, passing through France where we visited several refineries near Rouen. We were well received and shown many courtesies, but practically nothing was of interest to us as we have already solved the problems with which the French refineries are at present concerned (desulphuring of crude).

Arriving in New York, we arranged for our geologists to visit the Mid-Continent, Oklahoma, Louisiana and some of the oil fields in which geological formations resemble those of Soviet fields. Several of our production and refining engineers arranged to visit the Texas fields and later proceed to California to visit refineries and study production of high octane gasoline.

As for myself, I had to remain some time in New York to discuss current business with several American firms like Dubbs, Kellogg, Max Miller, Alco, Badgers, Lummus and others. Americans, as a rule, prefer to discuss business while taking lunch, between 12 and 1 o'clock, and during these luncheon engagements we practically completed most of our business deals.

Our inspection of U. S. refineries and cracking installations did not offer us anything new, owing to the fact that our Soviet two-furnace cracking units are not at all inferior to current technique of American manufacture and design. We were, however, surprised to find that of the 638 refineries spread all over the country, only 90 units have above 10,000 bbl. charging capacity per day. The larger portion of the others are mostly of medium and below-medium capacity, while some have only 200 bbl. capacity per day. We were under the impression that all the small refinery units had been done away with long ago and that nowadays only large and combined refineries were used.

We were likewise impressed by the fact that the total of 140,000,000 tons of U. S. crude production per annum is derived from so many fields and from such a large number of wells which produce very small quantities of oil. Among the 340,000 wells under operation and 20,000 wells drilled each year, some oil wells in Pennsylvania, Ohio and other states produce as little as 1½ to 2 bbl. of crude per day. The Pennsylvania and Ohio oil fields are very similar to the Soviet fields of Grozni.

Most of the U. S. oil wells are of medium and below-medium production at which deep pumping is utilized to the fullest extent. The equipment is simple and very serviceable. Mechanized production at wells 7,000 ft. deep and over was new to us, owing to the use of 4-valve, long type pumps, high quality pipe and the complete absence of compressors. We were also impressed by the absence of any human service even at larger fields. We inspected oil field groups where 30 to 100 wells were under operation managed by two or three supervisors who use motor cars for inspection tours. They later return to their offices in order to make the necessary reports and answer mail. We must mention here that Americans are very punctual in answering mail, making reply without delay almost immediately.

Each year a score or more new fields are discovered and immediately developed for commercial production. Medium or below-medium wells are never overlooked. Only occasional regions are discovered with flush production. The Rodessa field was discovered in 1935 and developed immediately. We visited Rodessa eight months after its discovery and found 150 wells under operation already producing some 65,000 bbl. of crude per day, while 70 more wells were almost completed or being drilled.

Today Rodessa field is experiencing a boom. Properties are bought and sold by hundreds of specialists in land speculation. Scores of automobiles and trailers loaded with household possessions are moving along the roads toward the oil field, bringing all sorts of artisans to settle in shacks or to build cafeterias, retaurants and barber-shops (Americans in all walks of life and occupations are gentlemen—they shave every day). Housing in this new field consists mostly of huts or even tents similar to those we had seen in Charlie Chaplin's picture "Modern Times." At present Rodessa field is operated in barbaric fashion entailing considerable waste, but there is no doubt that after a while operations will become more normal.

Soviet oil operators have a great deal to learn from American field practice, particularly as regards production. No time is spent in building power plants—they discover oil, install steam boilers and then drill. Boilers are placed on wooden supports or often on the ground. Arrangements immediately are made for the supply of equipment and necessary spare parts as well as of other commodities. Literally over-night temporary housing is provided, including restaurant service, barber shops and supply stores, which arrive together with the necessary equipment or even before.

On our return trip to Moscow aboard the NORMANDIE, we were surprised by the ship's steward at dinner first night out with a bottle of champagne and a letter from Max Miller wishing us a pleasant trip on behalf of the Duosol installation. The same was repeated during the next several days on behalf of the Barisol installation and contact plant, and finally we were asked to accept a bottle of champagne to their and our own health.

Economic Position of Refining in U. S.

Division of Output Between Large and Small Units—Progress of Cracking—Possible Future Developments—Crude Proration and Its Bearing on Refiners' Margin. *By Joseph E. Pogue**

THE size of the refining division of the petroleum industry is determined by the demand for its principal products and the technology available for meeting this demand. On May 23, 1936, the rated refinery capacity of the United States was 3,869,000 bbl. per day, through which 2,975,000 bbl. per day were being run. These figures suggest an unused capacity of 894,000 bbl. per day, or 23 percent; but the "idle" capacity is largely composed of inefficient, high-cost, obsolete units, little of which could be economically utilized to produce products of the quality in demand. Also the rated capacity of many plants tends to be larger than the over-all, working capacity. Effective refining facilities, therefore, are not now substantially in excess of requirements in terms of current and prospective demands. In fact an extensive program of refinery installations, largely of a replacement character, is under way, without which there would probably be a shortage of efficient capacity by 1937.

On January 1, 1935, there were 638 refining establishments in the United States, of which 435, representing 89 percent of the total capacity, were operating; 196 were idle; and 7 were under construction. Of the operating plants, 15.5 percent of their total capacity was represented by units with capacity of 100,000 bbl. per day or over; 18.6 percent, by units with capacity of 50,000 to 99,000 bbl. daily; 18.5 percent, by units of 25,000 to 49,000 bbl. daily; 25.2 percent, by units of 10,000 to 24,000 bbl. daily; and 22.2 percent, by units below 10,000 bbl. daily capacity. Thus, 98 plants represented 77.7 percent of the operating capacity of the country, while 337 plants accounted for 22.3 percent of the capacity. It is, therefore, seen that the refining division of the business characteristically runs to mass production. The operating advantage of sizeable units is not caused by inherent superiorities of physical size—small refineries can be constructed with the same physical efficiency as large ones—but is a derivative of the integrative pattern that the industrial development has followed. The raw material is drawn from thousands of producing units, processed in a few hundred plants, and then distributed in the form of products through tens of thousands of outlets. The bottle-neck aspect of the manufacturing function has given rise on occasion to the suggestion that the refinery is a better place for a production control than the well head where proration localizes the check on supply. During the operation of the petroleum code, a regulation of refinery intake was attempted as a supplementary control; but it should be observed that if proration succeeds in balancing crude oil production with the consumer demand for products, there can be no occasion for an additional barrier except for price-fixing objectives; and, moreover, the regulation of refinery throughput cannot cure the uneconomic practices of open flow and offset drilling that are a product of the untrammelled operation of the rule of capture.

The process of refining is relatively a capital enterprise, automatic to a high degree. In 1934, for each employee engaged in this division 8,721 bbl. of crude oil were processed and around $33,000 of capital were engaged. The investment in the refining division, including inventories,[1] has been estimated at $3,400,000,000.

Petroleum refineries are located in 33 states, but 82.9 percent of the total operating capacity is concentrated in 8 states: Texas (25.1 percent), California (21.0 percent), Pennsylvania (8.2 percent), New Jersey (7.2 percent), Oklahoma (6.8 percent), Indiana (5.3 percent), Louisiana (4.8 percent), and Kansas (4.5 percent). In March, 1936, 38.8 percent of the gasoline output was produced in the Atlantic and Gulf coastal region; 16.7 percent in California; and 44.5 percent in the interior of the country. Thus over half of our gasoline supply is manufactured in plants on deep water, reflecting the importance of tanker transportation in determining the geographic location of the industry.

The technical changes that have taken place in refining are most complicated. Lack of space prevents analysis of all but three developments that have either exerted a deep impression upon the art or promise to do so as time goes on. The first of these, cracking, has revolutionized the quantity and quality of the recovery of gasoline from a barrel of crude; the second, polymerization, just geting under way, brings into view as prospective motor fuel a range of gaseous hydrocarbons now utilized for inferior purposes; the third, hydrogenation, which

SINCE the United States still produces over 60 percent of the world's annual supply of petroleum, it naturally exceeds all other countries in the extent of its refining capacity and the number of its refineries. In the accompanying article Joseph E. Pogue presents a summary of this branch of the industry with a brief discussion of its economic position and technical trend. The author is well known throughout the industry as a consulting engineer and economist of note and his name is familiar to readers of WORLD PETROLEUM through past contributions to its pages. A striking recognition of the authoritative position occupied by Mr. Pogue is contained in the recent announcement by the Chase National Bank of New York of his appointment as Vice President of that institution.

* Extracted from paper presented before International Power Conference, September 1936.

[1] National Petroleum News, Feb. 5, 1936.

still awaits the proper economic setting, permits an interchangeability and flexibility in manufacturing and renders available a range of raw material extending beyond the field of petroleum.

As its name implies, cracking breaks down the heavier molecules of fuel oil and distillates into gasolines of high antiknock qualities. In 1920 the output of cracked gasoline was only 15,000,000 bbl. as compared with 101,000,000 bbl. of gasoline derived from crude oil by ordinary processes of distillation. In 1935, the production of cracked gasoline had arisen to 208,000,000 bbl., or nearly equal in volume to the 220,000,000 bbl. of the straight-run product. Expressed in another way, cracking has enabled the recovery of gasoline from crude oil to increase from 26 percent in 1920 to 44 percent in 1935, and the trend of increased recovery is still upward. From an economic standpoint, cracking converts a product of inferior value into one of higher worth, and progress in its application has been determined by the course of price margins and developments in the technique.

Polymerization is a much newer process in its commercial application and has yet to make its impression upon the industry. Technically it is the complete reverse of cracking; it utilizes as its raw material the hydrocarbons lighter than gasoline and combines these into larger molecules of the gasoline family, in so doing also creating high antiknock quality. The raw materials now suitable for this process are waste refinery products and some of the components of natural gas, such as butane and propane. Eventually the art may be expected to evolve to the point of utilizing the vastly more abundant but still lighter components of natural gas, at which time a further source of raw material will be available for the manufacture of motor fuel. For many years the natural gasoline occluded in oil-field gas has been extracted in growing degree from this material, adding materially to the output of motor fuel. For example, natural-gasoline production has increased from 9,000,000 bbl. in 1920 to 39,000,000 bbl. in 1935. With some installations already made, polymerization will contribute a small volume of gasoline in 1936 to the annual total. It has been estimated [2] that the ultimate potentialities of the process operating on both refinery and natural gases are 110,000,000 bbl. and 78,000,000 bbl., respectively, or a total of 188,000,000 bbl. This volume is 40 percent of the output of motor fuel in 1935.

While cracking has long enjoyed important commercial application and polymerization is undergoing initiation, hydrogenation, developed in Europe, is awaiting the stimulus of higher prices for intensive development. The process permits great flexibility in the conversion of crude oil into the products most in demand and also enables carbon compounds (coal) to be changed into hydrocarbons (oil). Costs are still too high for general application, but a moderate lift in prices, together with improvements now under way along the lines of lowered costs, will create margins that will stimulate its introduction. Hydrogenation, therefore, may be regarded as a process in the offing, awaiting the arrival of economic conditions suitable to its intensive development. In conjunction with cracking and polymerization, hydrogenation will ultimately be capable commercially, as it now is technically, to convert crude oil completely into motor fuel.[3] The three processes outlined promise an ample supply of motor fuel for an indefinite period.

The outstanding economic problem faced by a productive activity is the maintenance of equilibrium between supply and demand. This problem presents specialized features in the case of an activity involving multiple production and a range of by-products. Not only must the main product be kept in balance but sufficient flexibility must be developed so that the by-products will be carried off in trade in the proportions in which they must be manufactured. In the case of petroleum, gasoline is the main product and the other constituents are the by-products. Primary balance must be attained in respect to gasoline, but shortages or overages of other products, such as fuel oil, develop at times and create disequilibria. The mechanism by which these distortions are corrected is price, which operates to regulate demand and, through technical adaptations, to influence supply. The need of flexible prices in a by-product industry is imperative. A balance between supply and demand in respect to the main product, gasoline, is effectuated by price under freely competitive conditions, but with the operation of proration and a crude-oil quota system, this balance can be attained automatically, provided the freedom of gasoline prices is not interfered with and crude-oil quotas are based upon estimates of the consumer demand for gasoline. The crude-oil quotas suggested to the industry by the United States Bureau of Mines are computed on this principle and are far superior in workability to quotas based upon nominations of refiners, which the states used to accept as evidences of market demand. On a favorable price level, overproduction of gasoline cannot be prevented from developing, under proration, unless crude-oil supply is regulated on the basis of the consumer demand for gasoline. The refiner's demand for crude is a false criterion.

Another problem facing the refining division, with proration operating, is the resultant of a differential rigidity as between crude-oil prices and products' prices. Proration tends to result in greater stability in crude-oil prices than in products' prices, for the reason that the supply of crude oil is not always held within adequate balance with the estimates of consumer demand for products. In consequence, price disparities tend to develop. For example, the refiners' margin, calculated on the basis of the wholesale values of the products derived from a typical barrel of Mid-Continent crude oil, has displayed the following trend:

Refiners' Margin Per Barrel
Mid-Continent Crude

Year	Price of crude (*Dollars per barrel*)	Realization on products (*Dollars per barrel*)	Refiners' margin (*Dollars per barrel*)
1928	1.32	1.95	0.63
1929	1.36	1.99	.63
1930	1.23	1.70	.47
1931	.63	.98	.35
1932	.87	1.22	.35
1933	.62	1.06	.44
1934	1.00	1.35	.35
1935	1.00	1.53	.53

In 1930, 1932, and 1934, the refiner's margin was below his costs, despite crude-oil price levels above producing costs. The relationship, however, assumed more normal proportions in 1935. Disparities can be avoided by employing a sound quota system, such as that of the United States Bureau of Mines, and by the development of a crude-oil price structure more sensitive than it now is to changes in refining values. It is desirable, however, for disparities to develop if they are needed for a functional purpose, such as the expulsion of surplus capital from overexpanded situations or the prevention of overdevelopment.

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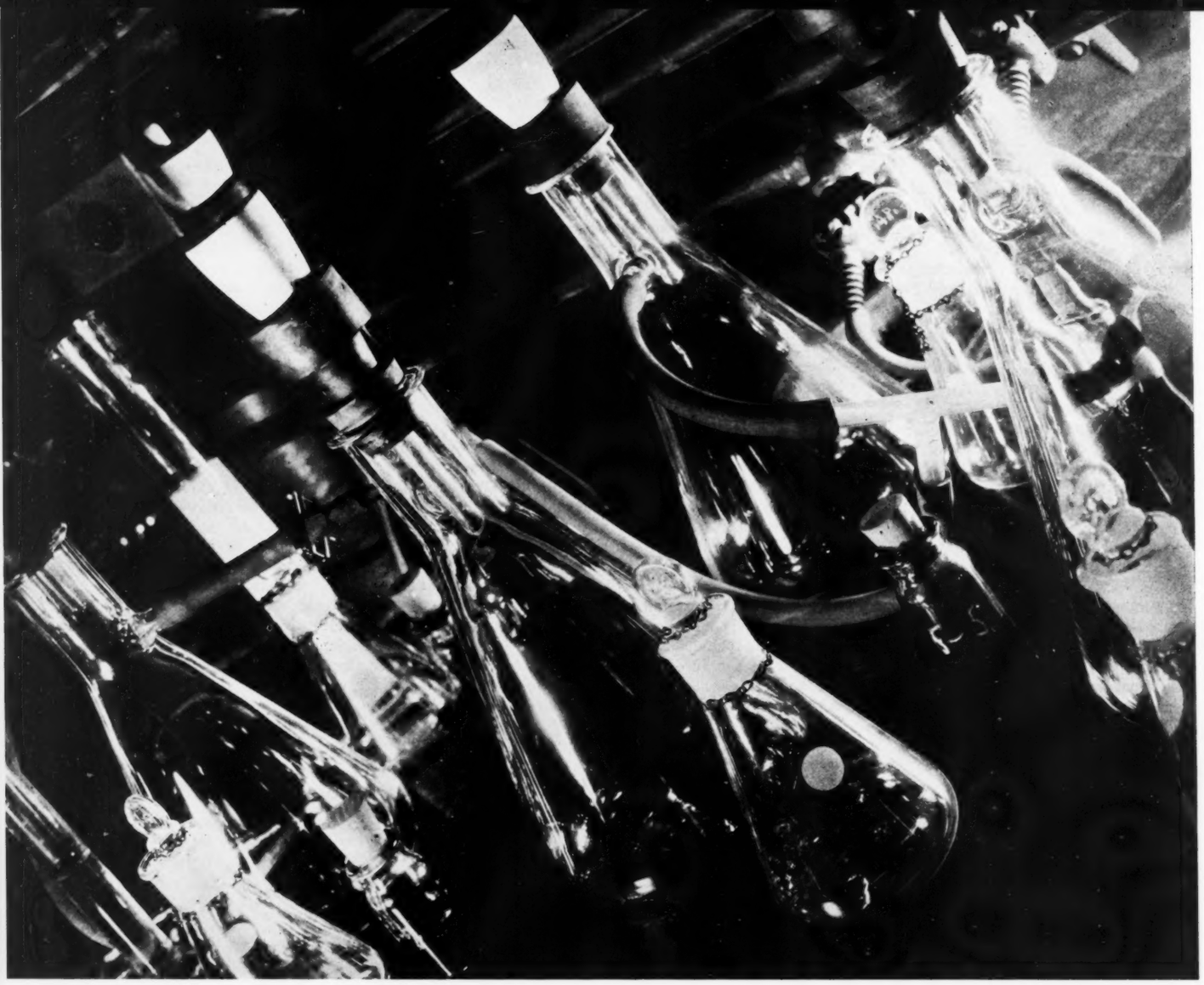
Front Cover Picture

OUR front cover picture this month is a recent study by Robert Yarnall Richie of a DeFlorez cracking unit which has been in operation for some time.

[2] Cook, Swanson, and Wagner, The Thermal Process for Polymerizing Olefin-Bearing Gases, Proceedings, Sixteenth Annual Meeting of the American Petroleum Institute, section 3, Refining, 1935.

[3] E. Ospina-Racines, Economic and Technical Aspects of Polymerization, *World Petroleum*, October 1935.



Research Costs and Trends

By W. C. Winning

Standard Oil Development Company.

IT IS of interest to speculate upon current expenditures for petroleum research by the petroleum industry. Egloff and Nelson at the World Power Conference, June 22–27, 1936, estimated that cracking research expenditures now exceed $5,000,000 per annum and that the investment in cracking equipment amounts to $400,000,000. Present production of cracked gasoline is placed at 250,000,000 bbl. per year, from which it appears that research costs for cracking amount to but 1.25 cents per dollar invested, or two cents per barrel of cracked gasoline produced.

Were these figures considered to be equally representative of all petroleum operations, then total research expenditures on refinery methods and equipment would be placed at some $42,500,000. This figure is obtained by applying the above factor of 1.25 cents per dollar invested to the $3,400,000,000 figure estimated by V. B. Guthrie in NATIONAL PETROLEUM NEWS of Feb. 5, 1936 (page 41), as representing the total domestic investment in refinery equipment. On the basis of private information available to us, this figure seems distinctly high, and if divided by two it would be about in line

with our own estimates. Furthermore, this sum would probably cover not only research on refinery equipment and methods, but also the extensive studies of product quality which are underway in many petroleum laboratories.

It is difficult to estimate with accuracy the distribution of these research expenditures, but a general impression may be obtained from the figures shown in Table I. To obtain these, a library bulletin of the Universal Oil Products Company for the year 1935 was thumbed through, noting the number of abstracts classifiable under each of the headings shown. In the table, the distribution is shown on a percentage basis. Items not lending themselves to this classification have been omitted, and the many references to analytical and routine testing methods have also been eliminated as presenting a distorted picture. The figures in the second column were obtained in a similar manner, taking the references from the annual Naphthology Review of the JOURNAL OF THE INSTITUTE OF PETROLEUM TECHNOLOGISTS. Unfortunately the review for 1935 is not available so that this percentage breakdown represents the year 1934. The third column was obtained similarly by a review of the bulletin put out by our own library covering all of 1935 and the first six months of the current year.

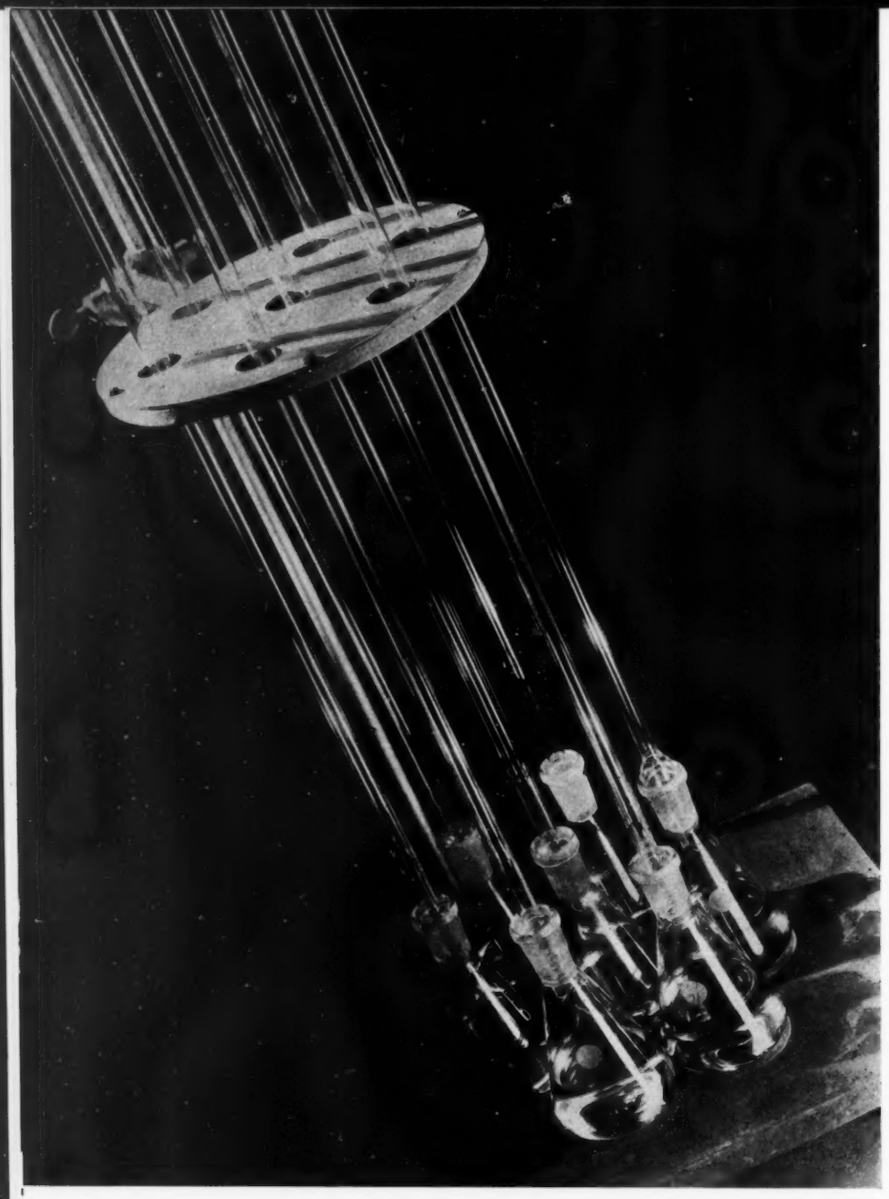
It should be noticed that in general the agreement is quite good, the biggest variation being reported for polymerization which has been sadly neglected by the J.I.P.T. and, perhaps, overly stressed by the U.O.P. An average of the three columns would represent quite well the actual research effort being made by the petroleum industry along the lines indicated.

As regards the trends of research, it is most apparent that major effort is being made to render the refiner independent of any particular feed source. Many years ago cracking was introduced to make possible the production of more gasoline than was available in the crude and more recently the emphasis in cracking has been directed to the control of operations so that not only can more gasoline be obtained, but further, this gasoline is modified along certain desirable lines, e.g. its octane number is raised or its volatility is controlled closely. The chemist no longer speaks of "cracking" alone, but of "isomerization" as well. Polymerization has also come into the picture not only as a method of converting gases into the more liquid fuels, but also as a means of synthesizing products of high octane number. It may be expected that in these closely associated fields of cracking, isomerization and polymerization, much progress will be made in the next few years.

A somewhat similar trend may be observed in the lubricating oil field where, by solvent extraction, it is now possible to make oils of high viscosity index from a large variety of crudes, and even Pennsylvania oils are being upgraded by this tool. It appears that the art of solvent extraction has now reached that point where no further marked technical development need be anticipated, though the application of this technique will doubtless become far more widespread. Solvent extraction, together with the more exacting requirements of modern engines has, however, made refiners increasingly conscious of the need for highly stable oils, and it is probable that much will be done during the next few years along the line of either so modifying extraction methods as to secure products of superior stability or to attain this desired end by the addition of anti-oxidants.

A second interesting trend is discovered upon examining the patents issued to the twelve major oil companies of this country over the period 1929 to 1935 inclusive. Table II gives a percentage breakdown of these patents under a number of headings used by Messrs. Brown and Wiezevich of

Robert Yarnell Richie



this company in a recent survey. Such processes as distillation and dewaxing have been included under refining; polymerization appears under fuels or lubricants, depending upon which it is applied to; and wax, asphalts, soluble oils, etc. are classified under specialties. When it is taken into account that many of the items included in Table I under fuels and lubricants have concerned themselves with the application of these products under a variety of conditions not susceptible to patent protection, it appears that the data of the two tables compare reasonably well. This particular survey emphasizes, however, the quite considerable attention given to chemicals by oil companies, and it should be noted that such important units in this field as the Carbide and Carbon Chemicals Company are not included.

A consideration of patents also emphasizes the point that these are rarely, if ever, so exploited as to work an unfair hardship upon any members of the industry. Thus in the case of tetraethyl lead whose superiority as a knock suppressor has never been challenged even most feebly, it may be observed that this product was made available to the industry at large at the earliest possible date and that there has been a steady trend to lower the cost to the refiner of using this material. Table III gives a review of the price schedule for tetraethyl lead as noted in NATIONAL PETROLEUM NEWS *28*, No. 29, page 20 (1936). Obviously this reduction in price has not been effected out of sheer benevolence, but rather the steady competition of cracking methods has been at least to some extent a factor. It may be presumed that so long as inventions are made there will always be more than one method of obtaining the sought-for end, and competition will always be keen enough to prevent the establishment of a burdensome monopoly.

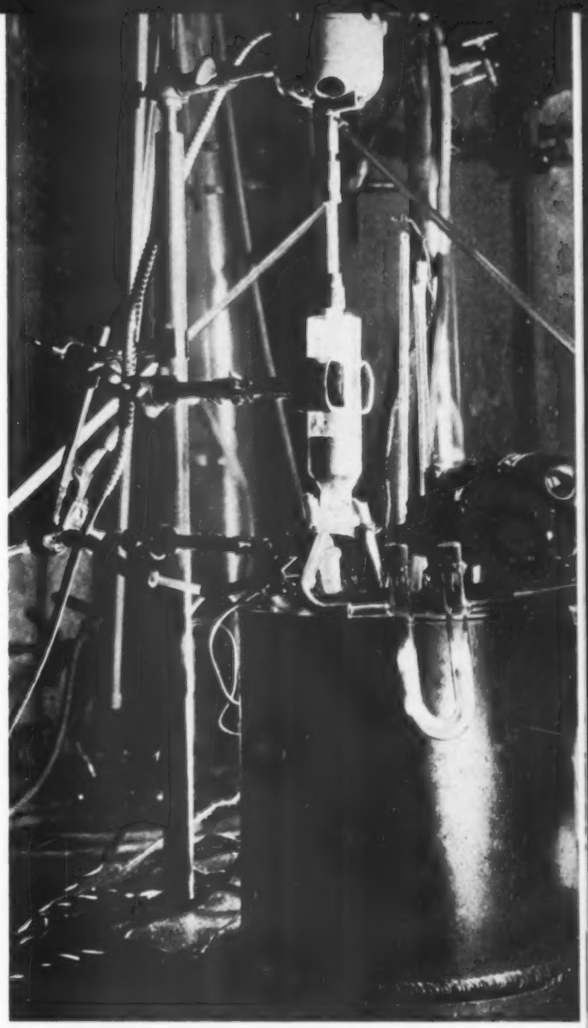
The tendency to make available to the industry at large all worthwhile developments is exemplified particularly well by the manner in which the hydrogenation rights acquired by the Standard Oil Company (New Jersey) from the I. G. Farbenindustrie A. G. were handled. The Hydro Patents Company was established and stock in this enterprise was issued to all domestic refiners interested in the process. Eighteen subscribed and by their contributions secured from the patentholders the exclusive right to license hydrogenation in the U.S.A. Thus complete control of this process is in the hands of American companies, that is, those organizations which are primarily interested in the use of this process.

The subject of patent agreements naturally arises at this point, and it is to be noted that these serve a number of pur-

Table I

Distribution of Petroleum Literature by Subjects

	U.O.P. Bulletin 1935	J. Inst. Petr. Ann. Naph. Rev. 1934	S. O. Dev. Library Bull. Jan. 1935–June 1936
Distillation and Absorption	6.2%	5.3%	6.4%
Cracking and Isomerization	13.8	10.4	15.1
Polymerization	9.0	0	4.3
Hydrogen & Hydrogenation	6.2	0.4	5.4
Refining, Fuels	4.6	12.8	17.9
" Lubes	8.3	7.8	
Dewaxing	0.8	2.7	3.7
Gas Utilization and Purification	4.2	3.3	3.7
Motors and Motor Fuels	18.7	14.1	17.1
Kerosene and Diesel Fuels	5.4	15.7	
Industrial Fuels	2.5	5.9	1.9
Lubricants and Lubrication	14.9	7.0	17.8
Asphalts	5.4	14.5	6.7
	100.0%	99.9%	100.0%



poses. Since any major operation usually receives the study of a number of competitive organizations each of them effects and patents improvements covering certain details. Obviously the basic operation such as, for instance, cracking, can be carried out most efficiently when all the improvements available can be employed, and consequently by pooling their interests the various parties involved may employ the best features developed by each.

Table II

Distribution of Patents of 12 Major Oil Companies

(1929–1935 inclusive)

Refining	41.9%	32.3%
Cracking	19.4	15.0
Hydrogenation	11.2	8.6
Fuels	6.1	4.7
Lubricants	7.2	5.6
Specialties	14.1	10.9
	99.9%	77.1%
Chemicals		11.8
Production		10.9
		99.8%

The situation is similarly simplified from a licensing standpoint. Today any refiner may license a cracking process in which practically every improvement has been incorporated. One license covers all of these, and there is no need of making separate arrangements with possibly twenty to a hundred different patentholders.

Furthermore, licensing is no longer subject to discrimination. Stubborn patentholders who would demand an exorbitant fee for some minor yet relatively essential feature are eliminated.

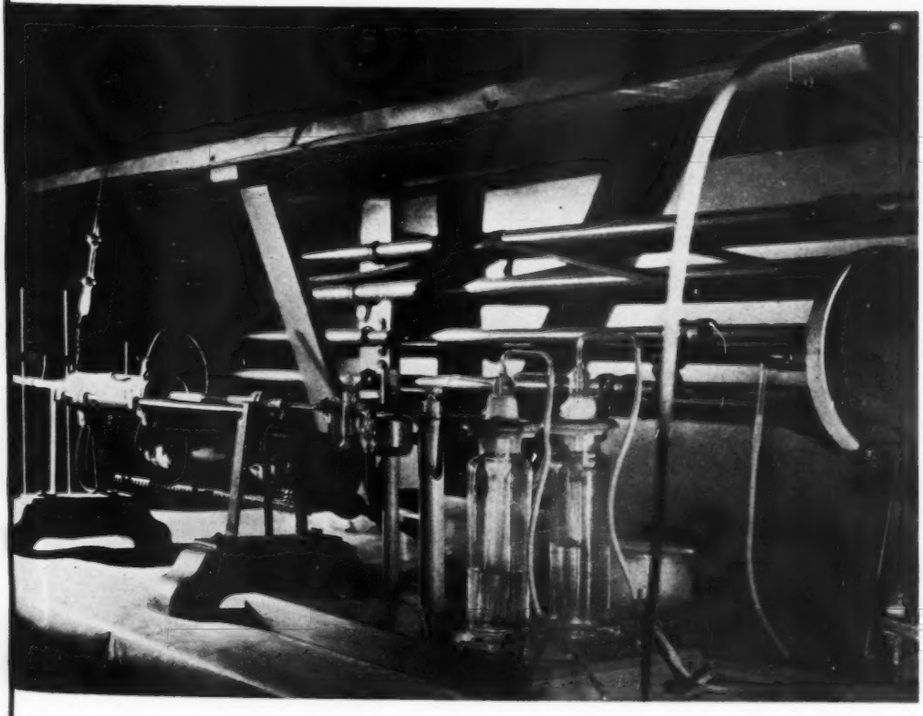
Table III

Cost of Tetra Ethyl Lead to Purchasers

	Fee/gallon (cents)	Price/cc. (cents)
1923–Oct. 1. 1928	0	1.0
Oct. 1, 1928–Aug. 15, 1929	0.7	0.5
Aug. 15, 1929–Jan. 1, 1930	0.6	0.4
Jan. 1, 1930–July 1, 1930	0.6	0.35
July 1, 1930–Mar. 1, 1932	0.5	0.35
Mar. 1, 1932–July 1, 1933	0.425	0.35
July 1, 1933–Jan. 1, 1934	0.2	0.35
Jan. 1, 1934–Dec. 1, 1934	0	0.35
Dec. 1, 1934–Dec. 1, 1935	0	0.30
Dec. 1, 1935–July 1, 1936	0	0.28
July 1, 1936–	0	0.26

Finally by making the various component inventions generally available, research aiming purely to avoid a particular patent is rather unnecessary. Consequently research activities flow into those channels where they can do the greatest good.

Another beneficial effect of patent licensing agreements is that cooperative research is stimulated. Frequently the members of such an agreement plan their research activities with the thought of avoiding duplication, and in certain instances research programs carried out at the mutual expense of those involved are instituted.



Other types of cooperative research are also receiving attention. Studies at Penn State sponsored by the Pennsylvania Grade Crude Oil Association is a typical example of a group of refiners united by community of interest fostering research.

Another variety of cooperative studies is that backed by the American Petroleum Institute. Research projects of too academic a nature to warrant the attention of individual companies are here carried out for the benefit of the entire industry by the contributions of its members.

Of probably growing importance are cooperative studies carried out in which the petroleum industry joins with others in fostering a research of the use of its products. The standardization activities of the American Society of Testing Materials and the C.F.R. Committee are important in this connection. It appears likely that in coming years many further programs will be instituted.

Costs of Polymer Gasoline

By E. Ospina-Racines

THE conversion of hydrocarbon gases into premium fuels by means of catalytic and thermal polymerization processes is an accomplished commercial practice. The past year witnessed the formal presentation of this technical achievement in the refining industry and its acceptance as result of increasing demand for motor fuels of improved combustion properties.

Present commercial practice of polymerizing hydrocarbon gases into gasoline incorporates the following essential steps: pretreatment of the raw material which involves concentration of the charge by eliminating the low molecular components; cracking and dehydrogenation to produce unsaturates; conversion of the unsaturates, an operation which may be carried out simultaneously with the production of these; further processing of the residue gas by recycling.

Hydrocarbon gases suitable for raw material may be derived from natural gas deposits, from topping crude oil and gas recovery systems in refineries and from cracking still operations.

Pretreatment of the raw material is dependent upon its source and the type of polymerization process employed. Thermal polymerization may process natural and refinery gases whether these carry a quantity of unsaturates or not. Catalytic polymerization is suitable for the conversion of cracking still gases or those carrying a quantity of unsaturates. While both methods of conversion permit the direct processing of gases as derived from their source, reduced operating costs and greater yields are obtained by eliminating the low molecular weight hydrocarbons and charging the liquefiable components.

Present practice resorts to the elimination of methane and ethane, one and two carbon hydrocarbons. In the utilization of natural gas this preliminary step calls for the processing by absorbtion of large volumes of gas, inasmuch as methane and ethane are the preponderant constituents of natural gas and the liquefiable components do not exceed in general ten to fifteen percent of the original volume. Gases derived from topping crude oil and recovery systems in refineries is a raw material richer in essential components than natural gas, and the conversion of this material into polymer gasoline is more economically justifiable than natural gas because, although a low value raw material, it is one already obtained at greater cost. Since cracking still gases carry an abundant quantity of unsaturates the use of this raw material has certain technical and economic advantages.

Conversion of the raw material into polymer gasoline is carried out by heat and pressure and through the use of catalysts. Conversion by thermal means is brought about by subjecting the charge to elevated temperatures, as high as 1300 deg. F. and pressure of 1200 lbs. per square inch, factors which call for equipment highly resistant to the severe conditions

An 80,000 bbl. modern motor fuel storage tank.

© Robert Yarnall Richie

these imply. Thermal processes possess the flexibility of incorporating simultaneous production and polymerization of unsaturates. By proper control, such opposing reactions may be carried out effectively, just as takes place in the destructive hydrogenation of oil.

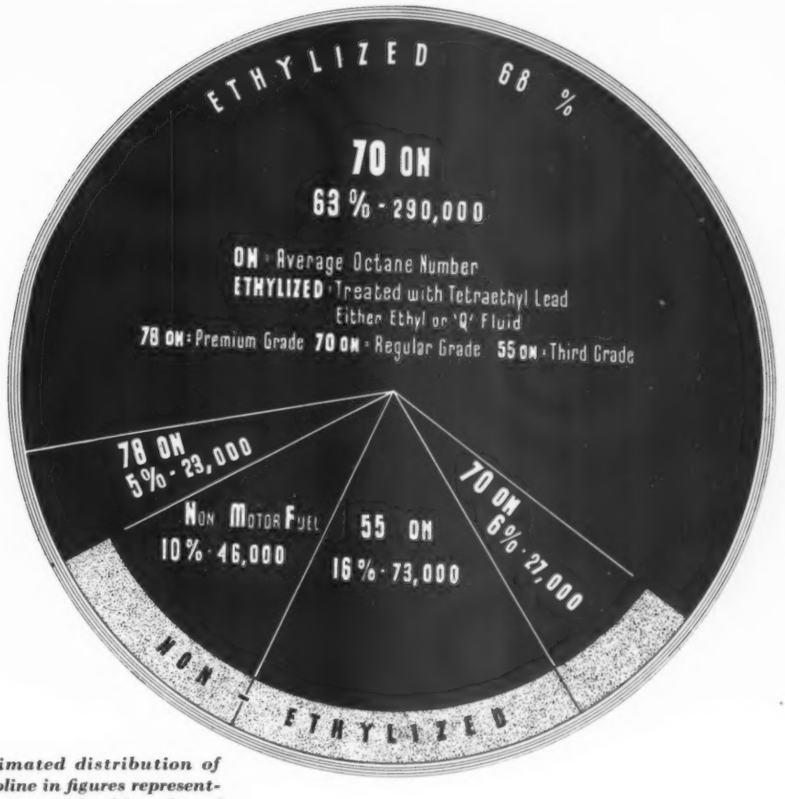
Conversion through the use of catalysts presents a contrast in the fact that notably lower temperatures are adequate, not exceeding 500 deg. F. and pressures are not greater than 200 lbs. per square inch. The contrast is significant in the fuel and power consumption of the process and in the difference of outlay for special construction materials and capital investment. Catalytic polymerization is suitable for a raw material already carrying a quantity of unsaturates, since simultaneous opposing reactions as carried out by the thermal process do not take place at the moderate temperatures utilized and in the presence of a polymerizing catalyst. The moderate conditions under which the process operates, the fact that the cracking still gases may be used directly without concentration of the charge and that these already carry a quantity of unsaturates, are factors significant in the economy of catalytic polymerization. The replenishing of the active catalyst after this agent becomes inert, however, is an added item of cost to be taken into account.

Present yields from commercial processes range from 2.8 to 14.4 gallons of crude polymer per thousand cubic feet of gas charged. The yields depend upon the concentration of the charge. When subjecting only three and four carbon hydrocarbons to polymerization, the yields are from 6 to 14.4 gallons per thousand cubic feet which on a weight basis represents a conversion of as much as 70 percent. This is remarkably high because in contrast, cracking, which is now a highly developed process, will convert into gasoline, by coking operation, at the most 55 percent by weight of the charging stock.

Theoretically one thousand cubic feet of hydrocarbon gases has a maximum yield, assuming one hundred percent conversion of the gas. If the hydrocarbon gases obey the perfect gas laws, at standard conditions of 60 deg. F. and 760 mm. one pound mole occupies 379.3 cubic feet. One gallon of 60 deg. A.P.I. gasoline weighs 6.15 pounds per gallon. With these data the theoretical yield, assuming complete conversion of the saturated components of natural and refinery gases would be as presented in Table 1.

The corresponding olefines would yield slightly less in proportion to their lower molecular weight.

The above data reveal the advantage of converting hydrocarbons of three and four


ETHYLIZED 68 %
70 ON
63 % - 290,000
ON - Average Octane Number
ETHYLIZED - Treated with Tetraethyl Lead
Either Ethyl or 'Q' Fluid
78 ON - Premium Grade 70 ON - Regular Grade 55 ON - Third Grade
78 ON
5% - 23,000
NON MOTOR FUEL
10% - 46,000
55 ON
16% - 73,000
70 ON
6% - 27,000
NON - ETHYLIZED

Estimated distribution of gasoline in figures representing thousands of barrels and percentages among the various octane classifications in the United States.

carbon atoms. For the same volumetric throughput a higher yield is theoretically possible, while in practice it is actually obtained in the polymerization of propane and butane. The data show that to obtain 24.8 gallons of polymer gasoline, theoretically it is necessary to convert 3,620 cubic feet of methane or 1,940 cubic feet of ethane, whereas utilizing butane only 1,000 cubic feet are required. The polymerization of butane by present methods does not yield more than 70 percent by weight or a maximum yield of 17.4 gallons of crude polymer whereas the maximum yield of methane of 21 percent by weight, gives only 1.44 gallons, the present limits of conversion. This observation points to the further advantage of utilizing the higher molecular weight raw material in view of the greater yields obtained.

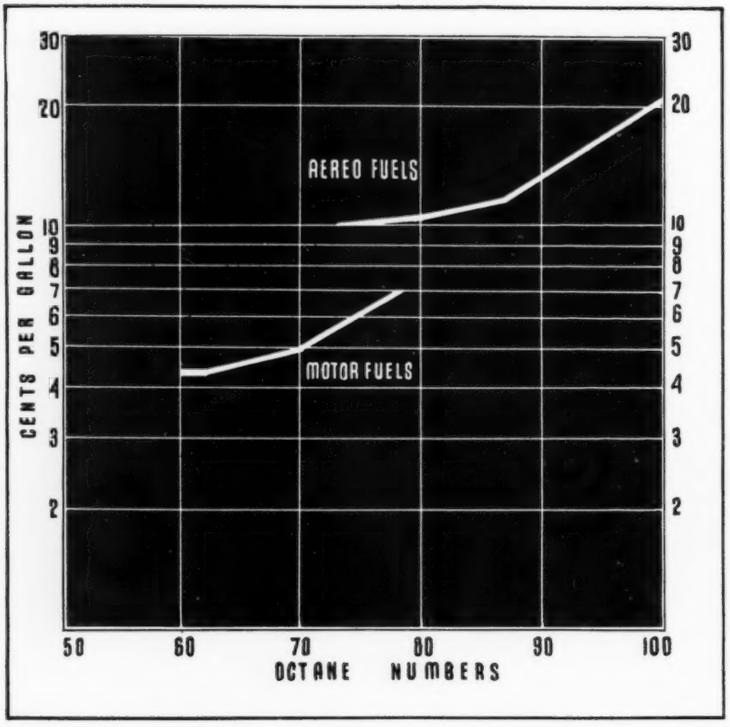
It is of interest to note, however, that one gallon of butane, of 0.58 specific gravity, can yield only 78.5 percent by volume of 60 deg. A.P.I. gasoline since the conversion results in a product having 0.74 specific gravity. Since present maximum yields are about 70 percent by weight, one gallon of butane results in a yield of 55 percent or about one half the original volume. This is significant in the cost analysis. If the raw material, butane, costs 3.20 cents at the refinery, in view of the 55 percent by volume yield, polymer gasoline certainly cannot cost less than 5.8 cents per gallon. This observation indicates that although the yield is high on a weight basis, sales and costs are based on volume realization; hence, the low volume yield is of economic importance.

Petroleum chemists have sought, and the search continues, for hydrocarbons which when blended with low octane gasolines, will promote the non-detonating properties of the fuel. Polymer gasoline is one answer to this search but, as yet, not a complete one.

In addition to being produced by a remarkable synthesis of hydrocarbons, polymer gasoline is outstanding because when

TABLE 1

Component	Molecular Weight	Weight of 1,000 Cu. Ft. pounds	Theoretical 100 percent Conversion into U.S. Gallons, 60° A.P.I. Gasoline	Cubic Feet Required To Equal Yield of Butane
Methane.....	16	42.2	6.9	3,620
Ethane.....	30	79.0	12.8	1,940
Propane.....	44	116.0	18.9	1,320
Butane.....	58	153.0	24.8	1,000



Present U. S. motor fuel price curve of the octane scale.

blended with low octane straight run gasolines it improves combustion properties. A singular fact of polymer gasoline in this respect is that the octane-promoting qualities of this agent are greater in gasolines of low octane rating and the effective value varies inversely as the octane rating of the gasoline of the blend. For instance a 55 octane gasoline with a blend of 35 percent polymer gasoline will register 70 octane number or a raise of 15 numbers; whereas a 70 octane number gasoline with a blend of 35 percent polymer gasoline will register about 80 octane number or an effective improvement of only two thirds.

An interesting fact about polymer gasoline is that its lead susceptibility is nil. In other words the most effective and widely used octane-promoter, tetraethyl lead, does not improve the octane properties of this product. In a blend, however, it reduces the quantity of tetraethyl lead required to improve the combustion properties of low octane fuels and its future principal use will be most likely in such role.

Since a polymer gasoline is more effective as an octane-promoting agent in low octane gasolines and is of unsaturated character, it is more suitable for motor fuel purposes than for use in aereo fuels.

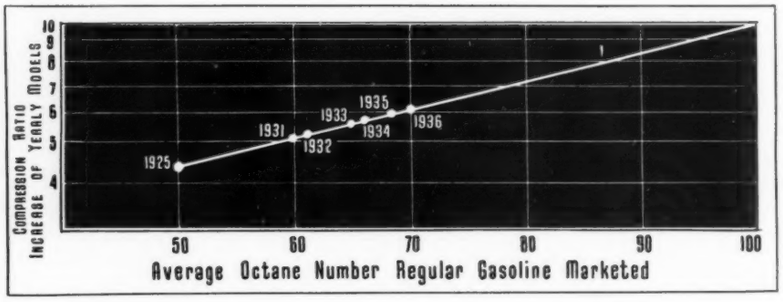
The polymerization process, however, opens avenues for the production of suitable aereo fuels and blending agents for these. The chemistry of the synthesis indicates that after polymerization this product may be selectively fractionated, then subjected to hydrogenation which will result in the production of saturated hydrocarbons such as commercial iso-octane. The saturated product in addition to having a possible 100 octane rating would be highly susceptible to lead treatment.

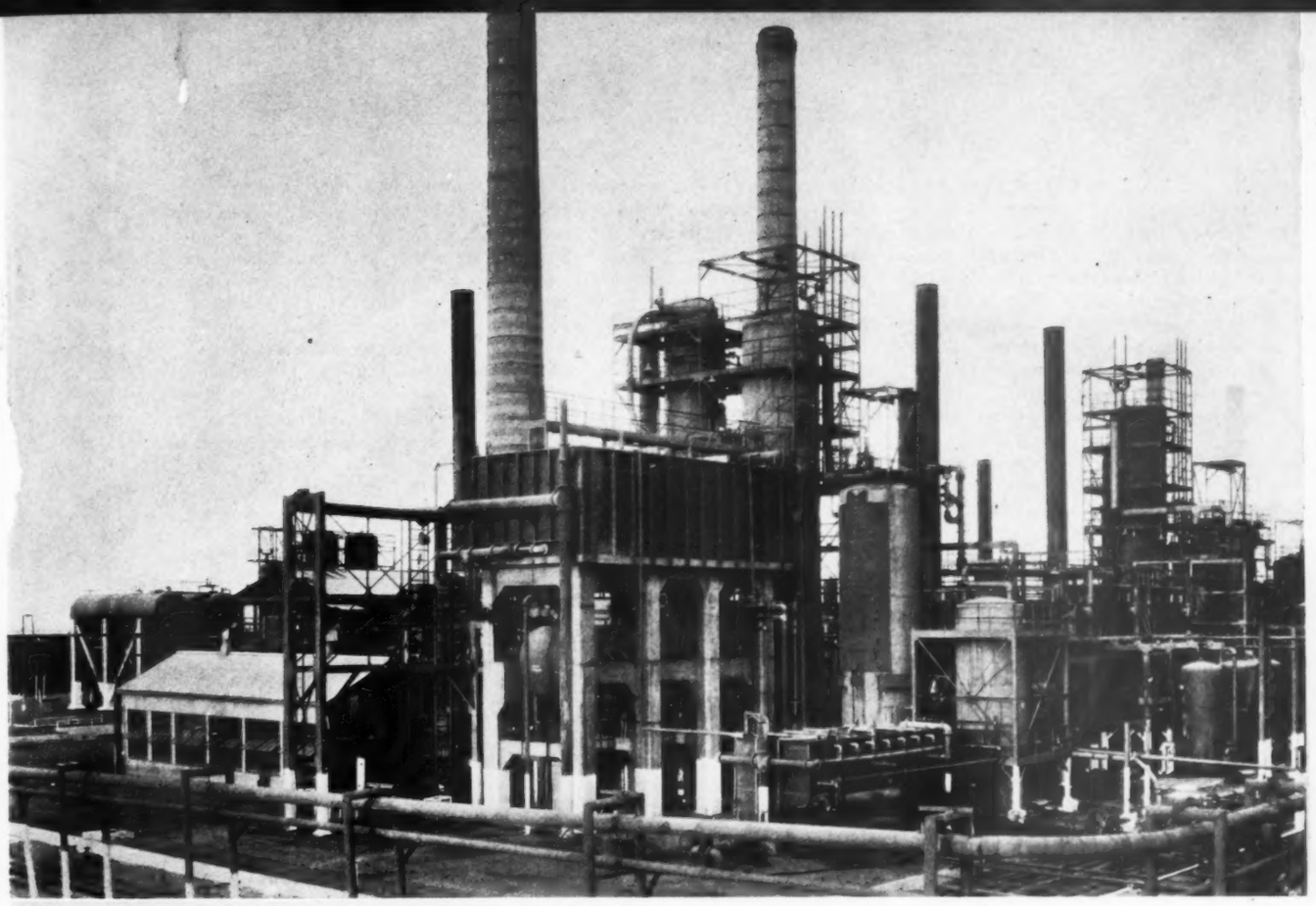
Trend of increasing compression ratio and octane number of regular grade gasoline marketed in the United States.

The trend in aereo fuels of high octane rating is in the production of fuels entirely of hydrocarbons with the minimum use of tetraethyl lead and no doubt eventually the elimination of this agent. Polymerization as a process producing high octane fuels entirely of hydrocarbons is in keeping with this trend and in conjunction with hydrogenation most likely will be the process meeting future aereo fuel requirements.

As a measure of conservation, polymerization of gases into gasoline will eventually prove one of the outstanding agencies. Not only does it convert refinery gases into gasoline, raw materials of low value yet of high cost, but upon improving the combustion properties of low octane number gasoline there accrues a measure of conservation in the increased efficiencies obtained while utilizing the resultant premium motor fuel in modern high compression engines.

The potentialities of polymer gasoline as a means of conservation may be appreciated by considering that present production of gasoline by topping and cracking is equivalent to about 45 percent of the amount of crude oil charged to stills. It will be appreciated therefore that every million barrels of polymer gasoline results in the conservation of approximately 2,222,000 bbl. of crude oil. In addition to this there results a conservation of crude oil by proper utilization of this gasoline of high octane rating. Since blending 35 percent of polymer gasoline with straight run low octane fuel improves the combustion properties of making this fuel suitable for modern engines, and the use of improved fuels have demonstrated savings of as much as ten percent in fuel consumption, the blending of 1,000,000 bbl. of polymer gasoline in the above proportions with low octane fuel may result in a saving of as much as 285,000 bbl. of gasoline. This in turn is equivalent to having proc-





Two of the new polymerization units at the plant of the Phillips Petroleum Co. at Borger, Texas.

essed about 635,000 bbl. of crude oil with present yields of refined products.

The production of 1,000,000 bbl. of polymer gasoline may effect a total saving of about 2,857,000 bbl. of crude oil. Conservation is thus attained in the oil industry by the technical progress in refining and secondly, supplemented by the automotive industry, in the design of efficient engines.

In recent years there has come about remarkable improvements in both motor and aero engines. Engine design has undergone great transformations, materials of construction have changed, engine speeds and power output are greater and efficiencies have greatly increased.

The most significant engine design improvement of recent years which has been the principal factor in obtaining greater efficiencies has been the constant increase in compression ratio, which in turn has called for higher octane fuels. Although a strict correlation between minimum octane fuel required and compression ratio of engines is not possible inasmuch as there are ten different factors that influence this relation, the graph on page 472, which depicts the constant increase of compression ratio of engines and the octane number of regular gasoline marketed as shown in the following schedule, is significant as to the trend of these variables.

TABLE II

Yearly Models	Average Value Compression Ratio	Regular Gasoline Marketed Octane Number
1925	4.40	..
1931	5.10	60
1932	5.29	61
1933	5.57	65
1934	5.72	67
1935	5.99	69
1936	6.15	70

The values of yearly compression ratios and the octane number of the fuel marketed show a straight line relation on semilogarithmic coordinates, as presented in the accompanying graph. Extending the trend of increased compression ratio, which will no doubt take place, it may be observed that when the average compression ratio of 7 to 1 is attained the regular gasoline marketed will most likely be of an octane rating of 78, or today's premium motor fuel rating.

Present engines with an average ratio of 6.12 to 1 apparently require a minimum of 70 octane fuel which today is the type most widely sold. The average car however is about five years old, which means that half the number of cars on the road are older than 1931 or models that operate efficiently on third grade gasoline of 60 octane. It is estimated that only 15 percent of present motor vehicles require a fuel of 70 octane or greater. Within five years the average car will be a 1936 model or more than half of the cars will be requiring a 70 octane fuel. Since there is available widely a fuel of 78 octane rating, regular gasoline will most likely remain around 70 until the number of cars requiring a higher rating justify an increase of the octane rating of this gasoline.

It may be observed that it took about five years to raise the octane rating of

regular gasoline, from 60 to 70, but most likely a shorter period will elapse between an increase from 70 to 80. Although premium fuels may be eventually marketed with a higher octane rating than 78, the present number, the differential of 8 octane numbers as prevails today between the premium and regular grades will be reduced. Increasing the compression ratio of motor car engines above 7 to 1 (the 78 octane marketing ratio), is not likely to take place in view of certain mechanical and construction difficulties encountered in higher ratios and the fact that an increase of the compression ratio from 7 to 1 to 8 to 1 does not result in a greater efficiency than about 5 percent. It is unlikely that motor car engine ratios will exceed 7 to 1 although greater efficiencies may be attained in the future by resorting to supercharge operation, similar to the practice on aereo engines.

Since the trend is in marketing higher octane fuels and polymer gasoline has the outstanding properties of promoting this characteristic when blended with low octane gasolines, the role of polymer gasoline as a blending agent in this respect should be of much interest. The data presented in the chart on page 471 depict the estimated octane motor fuel distribution in the United States in 1935.

It will be observed from the accompanying chart that five percent of the gasoline marketed was of premium grade or 78 octane number; sixty-nine percent is of regular grade or 70 octane rating; sixteen percent is of third grade with an average rating of 55 and ten percent is estimated to be utilized for other purposes than as motor fuel. Of the regular gasoline it is estimated that not more than six percent is marketed without the use of tetraethyl lead, thus leaving sixty three percent of the regular gasoline treated with lead.

There is therefore about sixteen percent or 73,500,000 bbl. of third grade gasoline requiring treatment to place it in the regular grade. Since it requires a minimum of thirty-five percent of polymer gasoline in the blend to improve this third grade product to a 70 octane rating, the potential market requirements call for about 39,508,000 bbl. of polymer gasoline per year.

However, the anomaly of the situation is, that the 73,500,000 bbl. of third grade gasoline represents a straight run product of small capacity refineries which most likely do not have cracking stills to furnish the raw material. Moreover, the production of third grade gasoline is distributed over the country and the octane number varies according to the source of the crude. Refineries not provided with cracking stills, producing third grade gasoline, are in a position to purchase either polymer gasoline or tetraethyl lead.

The significant technical and economic data of this is demonstrated in the accompanying Table III on page 479.

The ethylized gasoline of 70 octane number, or sixty-three percent of the total production, required on the average about 1.25 cc of lead per gallon to improve its combustion properties. This indicates that the average octane number of the base stock was about 60. Since it requires about 21 percent of polymer in the blend to bring a 60 octane number gasoline to 70, the potential market for polymer as an octane-promoter in competition with tetraethyl lead, is then about 82,000,000 bbl. per year. It is unlikely that polymer gasoline alone will be utilized for the production of premium fuels of 78 octane or more, inasmuch as the product itself has a rating of 78 to 82.

The total potential market at present for polymer gasoline as an octane-promoting agent in competition with tetraethyl lead is therefore 121,508,000 bbl. per year. This represents about 26.3 percent of total gasoline production of 1935.

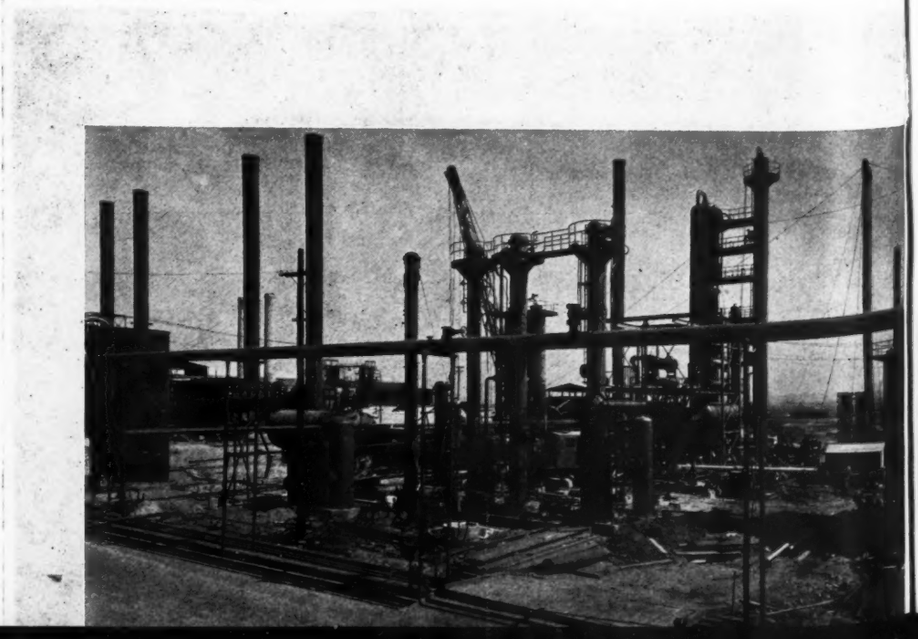
Since treatment with tetraethyl lead does not increase the volume of gasoline, the use of polymer product as an octane promoter would require increased sales of gasoline equivalent to the quantity produced or purchased or a reduction in the output of the refinery of other gasoline. The production of the potential market requirements to treat the present third grade gasoline would result in the displacement of 39,508,000 bbl. of ethylized 70 octane gasoline if there is no increase in consumption.

The potential market and the available quantity of polymer gasoline offer a contrast of considerable interest. Although the actual figures are of little significance at present, such computations are of interest as an indication of the ratios which may exist.

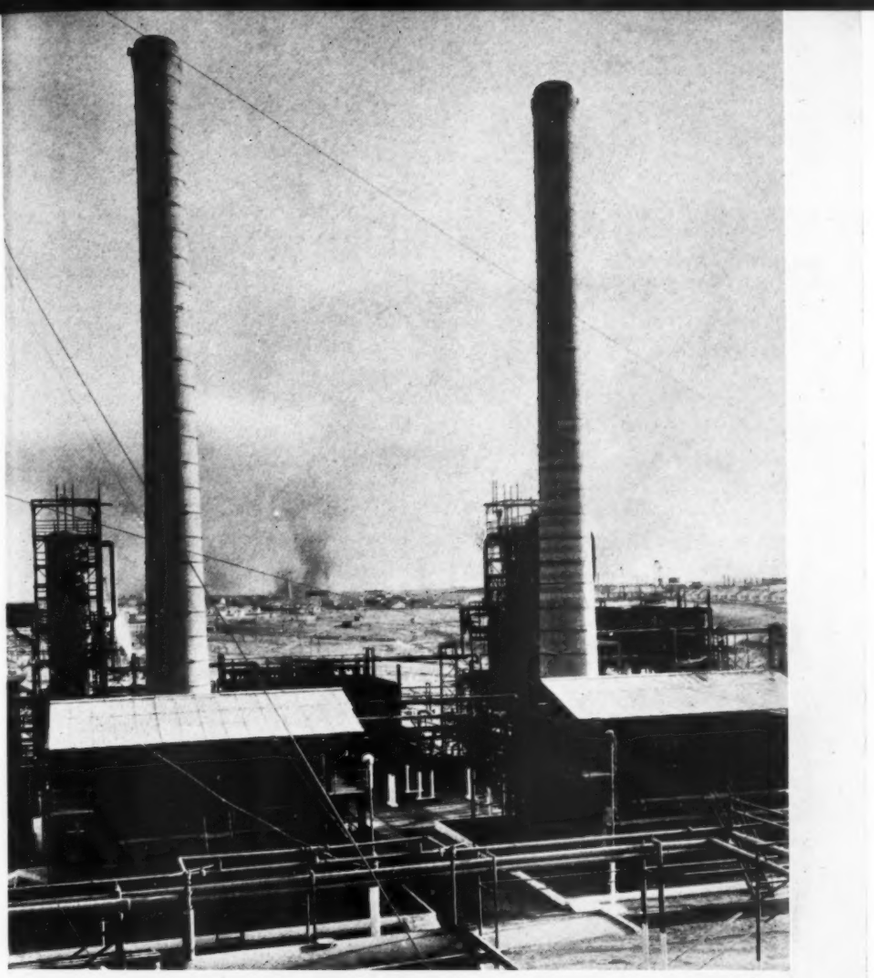
As mentioned previously the raw material may be derived from natural gas deposits and from refinery operations. Since present practice of polymerization resorts to the conversion of the liquefiable components derived from these sources it would seem that the potential production of polymer gasoline cannot exceed an amount that can be converted from current production of natural gasoline. According to statistics of the American Petroleum Institute the production of natural gasoline from these sources was 38,858,000 bbl. in 1935. The conversion of this product of 0.70 specific gravity would result in a yield not greater than sixty-five percent by volume or 25,200,000 bbl. of polymer gasoline. This assumes that natural gasoline production would be doubled to attend to this added demand. The potential market was computed at 121,508,000 bbl. per year whereas the above figure is only twenty-one percent of this market.

Going into the realms of speculation, the possible production may be computed on the basis of the polymer yield per thousand cubic feet of raw material processed and the production of six-hundred cubic feet of gas per barrel of oil charged to cracking stills in 1935. The potential quantity thus computed is equivalent to 33,800,000 bbl. of polymer gasoline per year. From other refinery operations the amount of hydrocarbon gases may be estimated as one-hundred cubic feet per barrel of oil charged to stills. From data of the A.P.I. this amounts to 96,624,300,000 cubic feet, and on the same conversion rate the potential quantity of polymer gasoline is about 11,500,000 bbl. per year. The total amounts to 37.5 percent of the above market figure.

The quantity available from natural gas should be based on the production of



Dubbs polymer plant in course of construction at Richmond Refinery of California Standard Oil Company.



Thermal poly plants at Borger, Texas turning out 2,000 bbl. of polymer gasoline per day for Phillips Petroleum Co.

natural gasoline, inasmuch as present practice resorts to the elimination of methane and ethane when utilizing this raw material. The average production of natural gasoline is about 0.9 gallon per thousand cubic feet and it is generally considered the limit between the classification of wet and dry natural gas. Polymerization of this product would yield not more than 65 percent by volume or 0.58 of a gallon per thousand cubic feet. The total yield is not greater than mentioned previously. The sum total of potential production is therefore about 70,500,000 bbl. or about 58 percent of the potential market. This indicates that the demand will be greater than the supply, a significant economic situation.

It may be pointed out that the potential amount of polymer should really be based on the available quantity of propane and its possible extraction from refinery and natural gases. Butane is finding wide use industrially and domestically; but because of the increasing quantities being blended and used alone as motor fuel this hydrocarbon may become unavailable as a raw material for polymerization. The only limiting factor in the greater utilization of butane in gasolines is the resultant increase in vapor pressure of the product. Since butane has a high octane rating and possesses all other desirable motor fuel characteristics, the polymerization of this hydrocarbon may be considered as merely a measure to reduce its vapor pressure to permit its utilization.

Since methane and ethane are technically eliminated and butane may be eventually displaced economically, propane becomes the future raw material for polymerization. However, other agencies such as the electric discharge, cathode rays and chemical reagents in combination with heat and pressure and e cient catalysts have demonstrated in the laboratory the conversion of one carbon atom and two carbon atom hydrocarbons into gasoline. There are therefore possibilities still pending which the future may develop to overcome the limitations of present processes.

From an economic point of view the role of polymer gasoline is dependent upon two factors, namely the percentage required in the blend for a definite octane improvement and the cost of producing this blending agent. If the cost of production at the refinery is equal to or less than the current price of the gasoline with which it is blended, there is little to impede its extensive application as an additional source of motor fuel. If polymer costs more than the current price of this gasoline it will be a direct competitor with other octane promoting agents. Since other agents such as benzol, alcohol, isopropyl ether, commercial iso-octane, cost far more than current low octane gasoline, have limited production and have certain technical limitations in their use, tetraethyl lead becomes at present the only competitor.

Table III shows the present competitive value of T.E.L. and polymer gasoline. This shows that polymer may cost as much as 6.30 cents per gallon in Mid-Continent to permit its use as an octane-promoter, and as much as 7.12 cents per gallon for treating Pennsylvania low octane gasoline.

In addition to the two factors mentioned above, from an economic point of view the role of polymer gasoline is dependent upon the trend in the diminishing cost of tetraethyl lead and increasing cost of motor fuels between 60 and 70 octane, wherein polymer is most economically effective and offers an opportunity of application.

The cost of tetraethyl lead has been constantly reduced. In 1930 treatment with

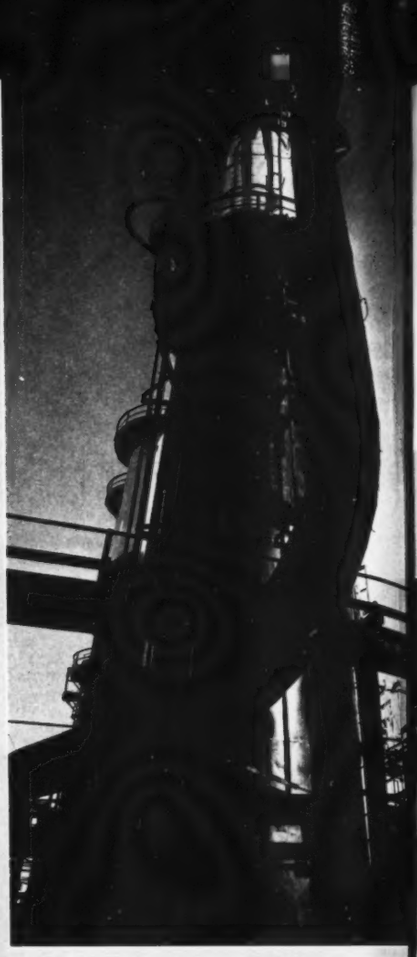
(Continued on page 559)

TABLE III

Source	Octane Number	Estimated Amount In Blend to Produce 70 Octane Fuel		Average Price at Refinery		Maximum Cost of Polymer to Compete with Lead 1935
		Polymer	T.E.L.	1935	1930	
Pennsylvania...	49	41%	3.00 cc/gal.	5.22	7.38	7.12
Mid-Continent.	52	36%	2.60 cc/gal.	4.42	6.35	6.30
California.....	63	16%	0.80 cc/gal.	5.53	8.07	6.84

World Wide Growth of Refining Capacity

Spread of Cracking and Trend to Combination Units Notable Developments.



STEADY expansion in total capacity, and particularly the growing adoption of combination units that top and crack the crude in a continuous operation, may be set down as the significant trend in refinery development in the United States during the past year. While the first polymerization plants were built little more than a year ago, they are spreading steadily and a greatly increased amount of attention is being directed to the production of 100 octane gasoline. Important additions are being made also to the number of solvent refining plants operating under various processes. Another notable tendency has been the multiplication of natural gasoline plants, bringing this branch of the industry to a more important position than it has occupied heretofore.

The spread of cracking is indicated by the great number of small plants that have installed cracking units during the year. On the Atlantic seaboard the cracking capacity of existing refineries is about 90 percent of the total crude oil capacity, while in the Mid-Continent the proportion has risen to 65 percent and in California to nearly 75 percent.

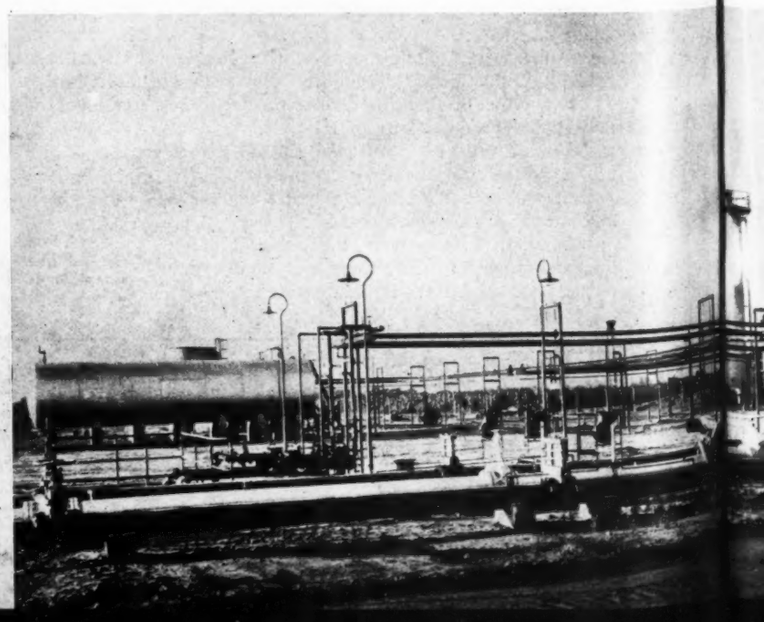
The movement toward combination units is illustrated by the action of Gulf Oil Corporation which was one of the pioneers in developing and adopting combination topping and cracking units, and probably processes more crude than any other one company on this type of equipment. The company has just completed conversion of seven large cracking units at its Port Arthur, Texas, refinery, into three combination units designed to top and crack a total of 50,000 bbl. of crude per day.

These units represent the most efficient and yet the most flexible design so far developed, and although the designed capacity is 50,000 bbl. per day, this will vary up and down depending on the volume of side cuts being removed from the system. The design of these units makes it possible to remove as side cuts lubricating fractions satisfactory for processing without any additional preparation in the way of re-running. This is a novel feature for a combination unit, as it is usually impossible to secure the proper degree of fractionation necessary on such stocks on this type of unit.

Careful selectivity and preparation of stocks ahead of each cracking coil insure maximum production of high-octane gasoline with minimum yield of gas and coke. Wet gases are absorbed by the lighter fractions ahead of cracking, and the gasoline production is stabilized at the unit, employing waste heat from the cracking operation.

These units are maintained on stream 2,000 hours, being shut down for the purpose of inspection rather than due to the necessity for cleaning.

Another example of the trend toward combination units is the 22,000 bbl. installation designed by M. W. Kellogg Co. for Atlantic Refining Co. at Atreco, Texas. This unit charges 38 deg. A.P.I. East Texas crude and in addition to topping, vis breaking, gas oil cracking, naphtha reforming, clay treating and stabilization, includes vacuum flashing of a portion of the fuel oil produced and thermal polymerization of product gases. Ordinary products made include straight-run depropanized gasoline, cracked stabilized gasoline, light virgin gas oil, fuel oil and gas. Provision has been made also



for withdrawing straight run naphtha and virgin gas oil.

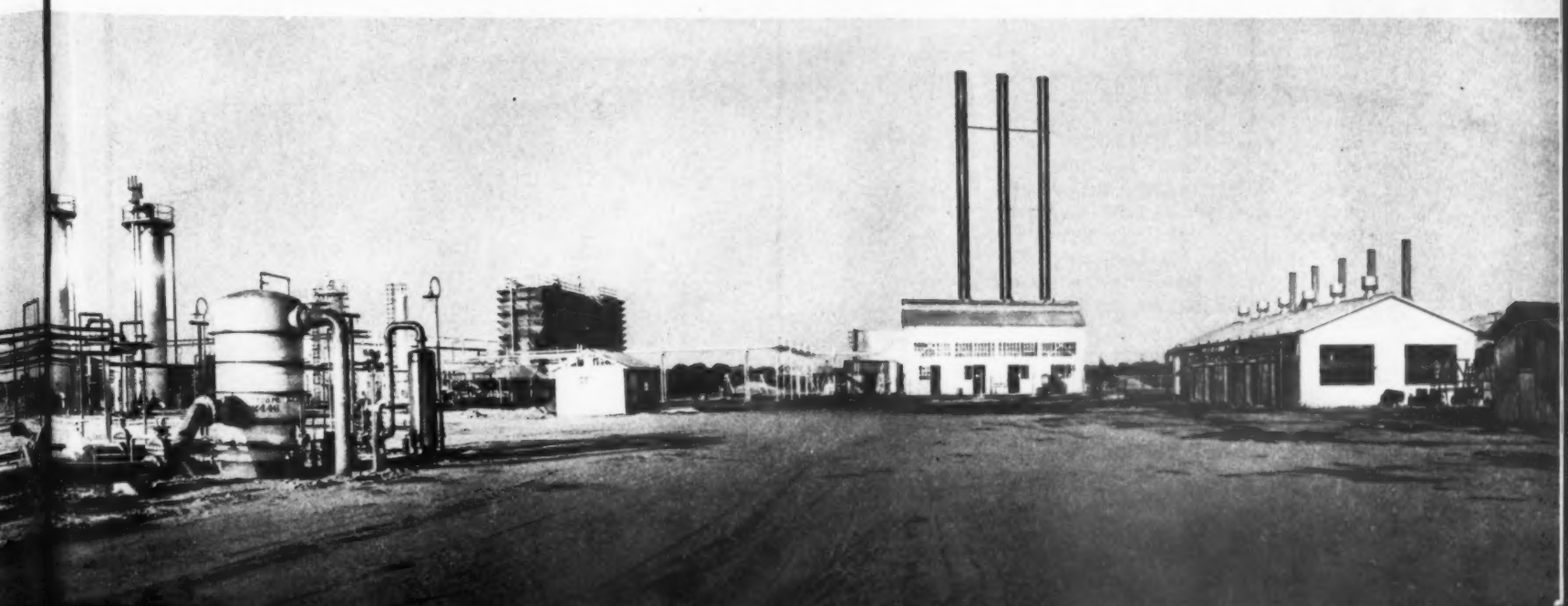
Turning to construction activities, a survey of the Pacific Coast reveals that the principal expansion of facilities during the past year in that area has come through the addition of units designed to increase capacity or to install special processes.

Conspicuous among these new units have been the polymerization plant of Standard Oil Company of California at Richmond, the iso-octane plant of Shell Oil Company at Dominguez, the Ethyl blending plant of St. Helen's Petroleum Company at its Pico refinery and the 12,000-bbl. re-run unit of Union Oil Company at Los Angeles. A number of important natural gasoline plants have been constructed, including one of 15,000,000 cu. ft. capacity for Shell Oil Company at Bakersfield and one of like capacity for Union Oil Company in the Dominguez field, both built by the Fluor Corporation. The same company has erected two 1,200 h.p. high pressure gas lift compressor units for Associated Oil Company at Ventura, California, and a 2,500 h.p. compressor unit for Industrial Fuel Supply Company in the Mountain View field.

Standard of California's polymer plant at Richmond is the first commercial installation of its kind on the Pacific Coast. It was constructed for the purpose of producing high-octane aviation fuel from cracking still gases. It embodies the Dubbs catalytic system and has a capacity of 700 bbl. per day of polymers, which in turn can be reprocessed, blended and leaded to produce 600 bbl. daily of 100 octane gasoline. Because of its type the plant can be operated at moderate temperatures and pressures, which in turn reduces hazards to a minimum. The plant is being constructed at a cost of over $600,000 and is now approaching completion. It is to be put in operation about November 1.

The most important construction enterprise of the year in California has been the completion by the Wilshire Oil Company

Texas Company's plant at Montebello, California, shown below.



of a completely new refinery at Santa Fe Springs, including a 12,000-bbl. combination skimming and Dubbs cracking unit, with absorption and gasoline stabilization equipment and a 5,900-bbl. centrifuge Stratford cold treating unit. The plant, which was constructed by the Ralph M. Parsons Company, includes also a 5,000-bbl. re-run unit, a doctor-treating plant, offices, shops, warehouses, laboratory and a special boiler plant of 2,000 h.p., besides a tank farm and a cooling tower 780 ft. long supplied by the Fluor Corporation.

The plant is so arranged that the topped crude, together with other straight-run products, can be charged to the cracking units and the distillation unit by-passed. The crude distillation is effected through heat exchange with the cracking plant, but provision has been made for the installation of a crude oil heater if it is considered desirable.

When charging 12,000 bbl. of crude, 4,000 bbl. of straight-run products, gasoline, kerosene and naphtha will be produced. The reduced crude from this operation is fed to the cracking equipment, which is of the full-flashing, two-coil selective type. A residuum flasher has been installed to reduce the gravity of the residuum produced, and the distillate taken overhead can be returned to the cracking unit.

A secondary fractionating column is incorporated with the cracking equipment to split the pressure distillate into light and heavy cuts. This phase of the process has been designed so that only the light half of the pressure distillate need be charged to the stabilizer, thereby greatly reducing the heat required. A vapor recovery system treats all the gases produced during cracking, thereby recovering valuable gasoline fractions.

The acid treating plant combines in one process the rapid dispersion and mixing of acid and distillate in contactors, followed by instant separation by means of centrifuges, all under conditions of low treating temperatures optionally regulated to desired levels. The process employed was selected because of its economical operation, its effective results in the removal of gums and the stability of its product.

Among other additions to California's refining facilities have been a 5,000-bbl. skimming plant of Bachmann Petroleum Company at Long Beach, a 2,000-bbl. skimming plant for El Tejon Refining Company at Mountain View and the enlargement of Mohawk Petroleum Company's refinery at Bakersfield at a cost of $500,000.

At Great Falls, Montana, a 750-bbl. Dubbs two-coil cracking unit, with absorption and gasoline stabilization equipment, U.O.P. treating unit, a vacuum asphalt unit and shop and warehouse facilities, has been constructed by Ralph M. Parsons Co. for the Home Oil & Refining Co. Its capacity is now being increased to 1,200 bbl. per day. Big West Oil Company, at Kevin, Montana, has enlarged its capacity by converting its 500-bbl. Dubbs single coil cracking unit to two-coil operation. Independent Refining Co. at Laurel, Montana, has erected under the supervision of Ralph M. Parsons Co., a 1,500-bbl. Dubbs single coil cracking unit and a 1,350-bbl. two stage vacuum flash asphalt unit.

Texas, as usual, has been the scene of much activity in the expansion of refining facilities. Besides a number of new plants, important additions have been made to the large refineries already operating in the states. One of the outstanding enterprises of the year was the construction by Pan American Petroleum & Refining Co. of a combination cracking unit and polymerization plant at its Texas City refinery on which the company expended $10,000,000. At Beaumont the Magnolia Petroleum Company has erected a 32,600-bbl. Kellogg cracking, refining and distilling plant. Pure Oil Company is building at Nederland, Texas, a 20,000-bbl. skimming and cracking plant. Shell Petroleum Co. has added a 20,000-bbl. Foster Wheeler topping and cracking unit to its Houston refinery.

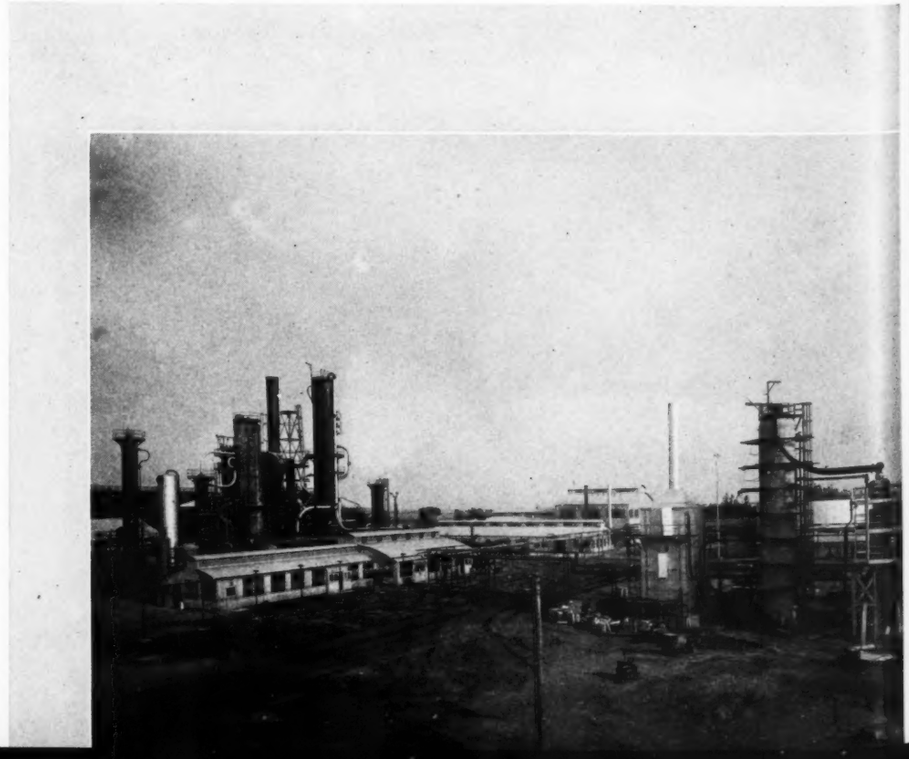
The Texas Company has been engaged in building a furfural solvent treating plant at Port Arthur. Humble Oil & Refining Company has installed at Baytown an Edeleanu sulphur dioxide solvent treating plant built by E. B. Badger & Sons. Atlantic Refining Company has added Gray clay treating units at Atreco, Texas. The same process has been introduced at the company's Franklin, Pa., Brunswick, Ga., and Philadelphia refineries.

A two stage topping unit handling 15,000 bbl. of East Texas crude has been constructed by Alco Products for the Crown Central Petroleum Co. at Houston. In order to provide a high degree of flexibility the secondary tower was designed for operation either at atmospheric pressure or under high vacuum. Particular attention was given to balancing the heat load. The tube still is of the radiant and convection type with separately fired radiant sections for close control of heat input for the primary and secondary stages.

Other new construction by Texas companies has included the erection of a 9,000-bbl. topping and 6,500-bbl. Dubbs cracking unit by the Eastern States Petroleum Co. at Houston, the increase in daily capacity of the East Texas Refining Company's Longview refinery from 10,000 to 20,000 bbl., the building of a 5,000-bbl. plant by Coastal Refineries at Port Isabel and a 2,000-bbl. plant for the Wood Moore Corporation at the same place.

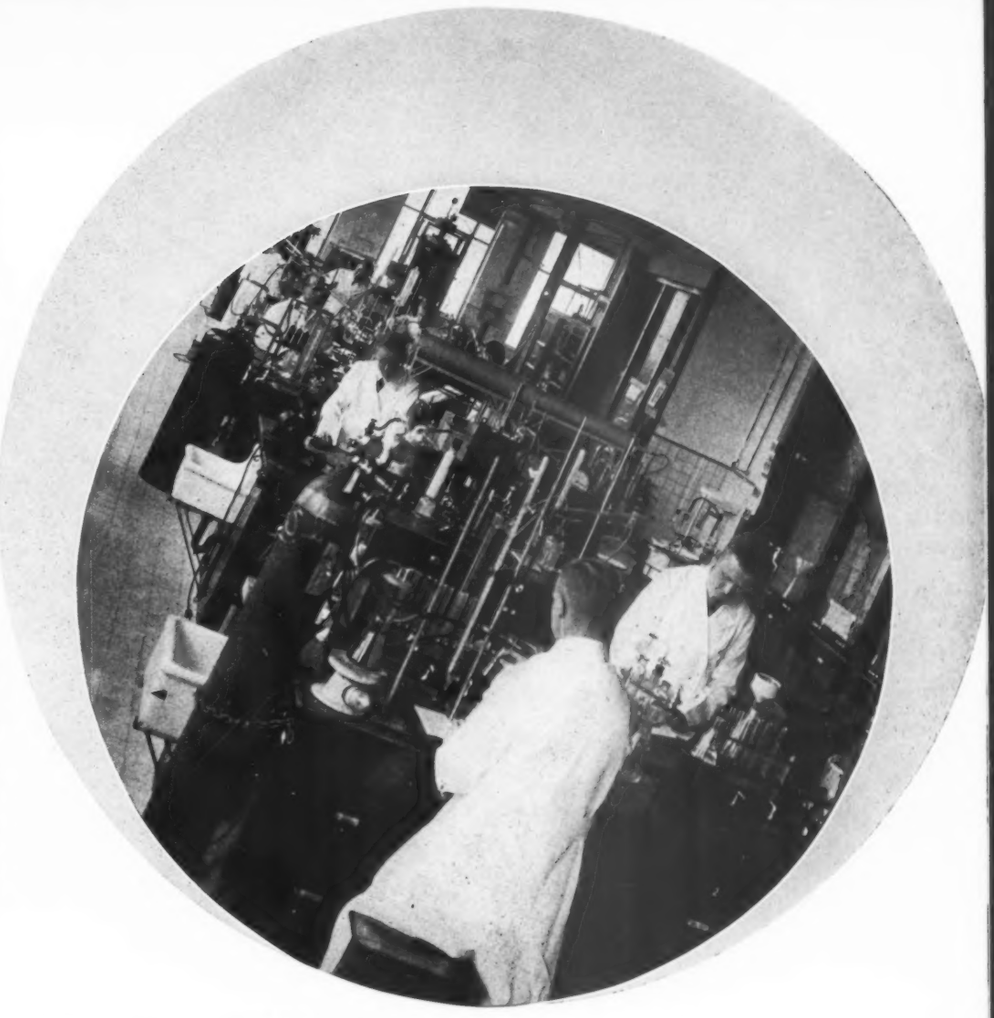
Phillips Petroleum Co. has built three polymerization units of 1,000 bbl. each at Borger, Texas, and one of 500 bbl. at Kansas City. Corpus Christi Refining Co. has installed a vapor recovery and

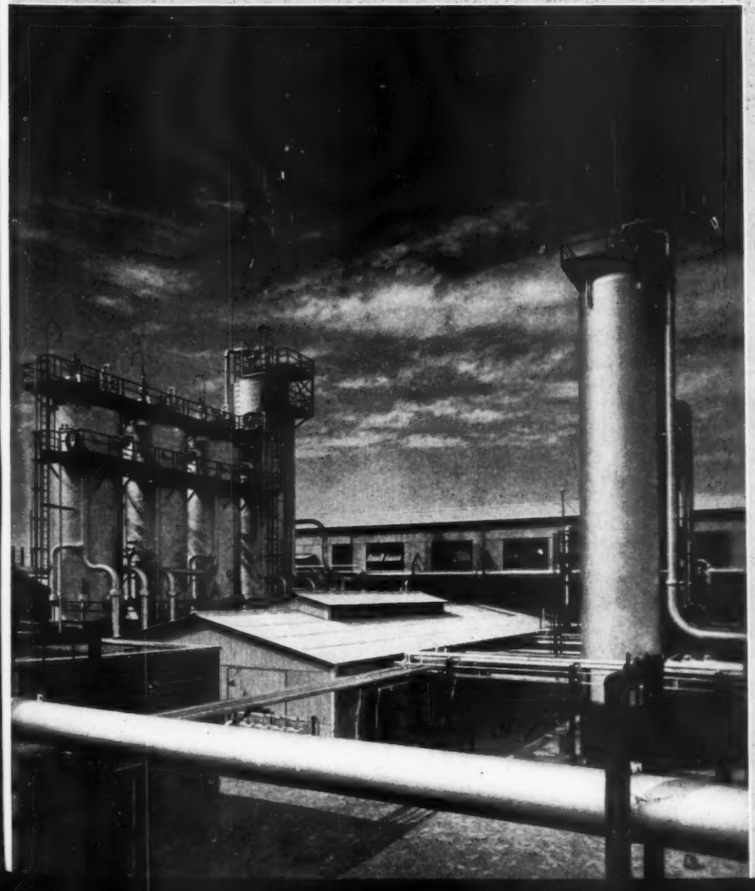
Below: Dubbs unit at Wiltshire's new Santa Fe Springs, California, refinery. On the opposite page are shown refinery workers in the Royal Dutch laboratory in Amsterdam, and Shell's deasphalting and dewaxing units at Wood River.



stabilization plant. Petrotex Co. has constructed a 5,000-bbl. topping plant at Texas City, utilizing the Donnelly process. Solvex Refineries Inc. has installed a 1,500-bbl. Dubbs cracking unit at Gladewater. A Dubbs polymer plant has been built by the Stearns Roger Co. at Amarillo for Shamrock Oil & Gas Corporation. Waggoner Refining Co. has installed a Dubbs stabilizer and absorption unit at Electra, Gainesville Refining Co. has erected a 2,000-bbl. skimming plant at Gainesville, Premier Refining Co. is building at Longview a 1,000,000-cu. ft. vapor rectification plant and an 800-bbl. pressure distillate stabilizing unit. Pethis Refining Co. has established a skimming plant of 1,000 bbl. daily capacity at Mathis, Texas. Natural gasoline plants of large capacity have been erected by Magnolia Petroleum Co. in Winkler County, by Standard Oil Co. of Texas and Gulf Oil Corporation in Ward County, by Manhattan Gasoline Co. in the Plymouth field in southwest Texas, and by Gillilan General Crude Oil Co. at Kilgore.

Rapid expansion of production in the Rodessa field has led to the erection of a number of natural gasoline plants in that area. At El Dorado the Skelly Oil Co. has installed a 15,000-bbl. distillation unit with Alcorn furnace. Barnsdall





Refineries added a Dubbs cracking unit to its plant at Wichita, Kansas. Derby Oil Co. of Wichita has installed a 6,000-bbl. tube still topping unit. Near Liberal, Kansas, Panhandle Eastern Pipe Line Co. is building a gasoline absorption and gas dehydration plant to handle ultimately 200,000,000 cu. ft. daily. At Wood River, Ill., Shell Petroleum Co. has added an iso-octane plant to its refinery.

Numerous additions have been made to refining capacity in the Michigan field. These have included the design and construction by Ralph M. Parsons Co. of a Dubbs two coil cracking unit with absorption and gasoline stabilization equipment for Leonard Refineries at Alma; a crude distillation unit for Roosevelt Oil Co. at Mt. Pleasant, increasing the capacity of the refinery to 4,400 bbl. daily and providing facilities for manufacturing special naphtha cuts, and a Dubbs cracking unit at Naph-Sol Refining Co., Muskegon, of 1,100 bbl. daily capacity.

A TVP vapor phase cracking unit of 1,500 bbl. capacity has been installed by Old Dutch Refining Co. of Muskegon. For McClanahan Refineries, at St. Louis, a 1,250-bbl. Dubbs cracking unit has been constructed under the engineering supervision of Arthur G. McKee & Co. Sweet Oil Refining Co. has erected a 1,200-bbl. distillation unit at Wyman. Other new enterprises in Michigan are the 2,000-bbl. plant of Pentagon Oil Co. near Detroit, the 1,500-bbl. skimming plant of Swanson Co. at Battle Creek, the vapor phase cracking unit of Inter Lakes Refining Co. at Flat Rock, and the 1,000-bbl. plant of Wolverine Petroleum Co. at Alma. A 1,500-bbl. plant has been constructed by Inland Refineries at Drayton Plains and a 1,200-bbl. plant by American Petro Chemical Co. at Wayne.

Two large operations are under way at Toledo, Ohio. One of these is the construction of a 12,000-bbl. daily capacity distilling and cracking unit which Standard Oil Co. of Ohio has under way. The other is the construction of a combination cracking and reforming unit which is being built by The Lummus Company for Pure Oil Co. At Findlay, Ohio, National Refining Co. is doubling the present 3,200-bbl. capacity of its plant by addition of an atmospheric vacuum distillation unit. H. A. Montgomery Co. of Detroit is building a lube oil refinery of 1,000 bbl. daily capacity at Findlay.

In the Pennsylvania field particular attention has been given to solvent refining and dewaxing plants. At Bradford a solvent dewaxing and deresinating plant has been built by M. W. Kellogg Co. for the Kendall Refining Co. and a dewaxing plant has been constructed by E. B. Badger & Sons for the Quaker State Oil Co.

An installation of particular interest because it is designed to utilize both Pennsylvania and Mid-Continent crude is the combination Gyro topping and cracking unit constructed by Alco Products for the Pure Oil Co. at Cabin Creek, W. Va. The crude unit has been designed to recover gasoline, naphtha, kerosene, furnace oil, wax distillate, slop wax and cylinder stock bottoms from 2,000 bbl. per day of blended Pennsylvania crude, and consists of a single flash multi-side stream distillation unit with provision for crude settling under temperature to reduce the carbon residue of the cylinder stock to a minimum.

The cracking and reforming units have been designed primarily for the production of gasoline and fuel oil, processing 1,500 bbl. daily of Mid-Continent crude and simultaneously processing the products from the blended Pennsylvania crude. The entire plant is constructed to give the maximum degree of flexibility.

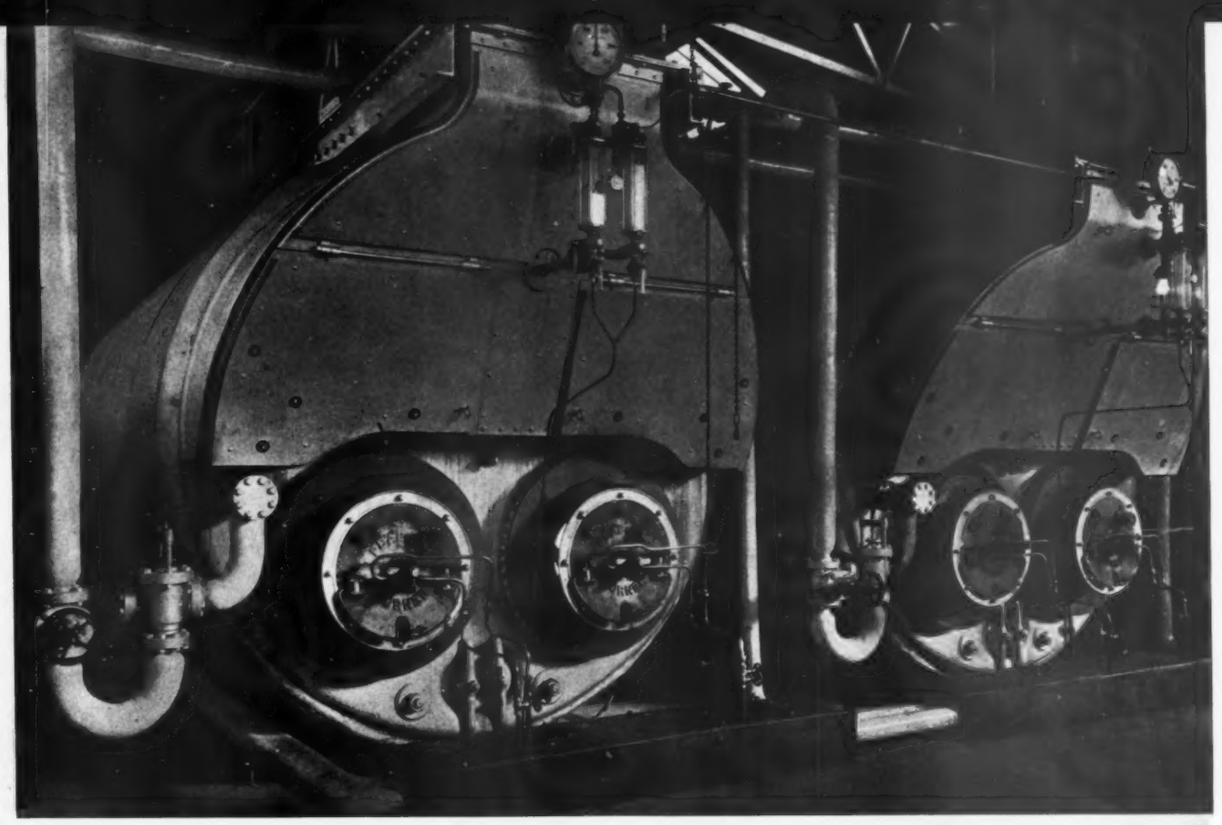
Pennzoil Company has erected at Rouseville, Pa., a 4,000-bbl. atmospheric distillation unit built by Alco Products for handling Pennsylvania crude. This installation replaced an old battery of shell stills and was installed to take advantage of the great economies which it made possible. A duplicate of this plant to serve as a utility unit for crude or re-run operations and to make special products has since been ordered by the company.

A 500-bbl. Dubbs cracking plant has been installed by Freedom Oil Works at Freedom and an 800-bbl. Dubbs cracking unit by Elk Refining Co. at Falling Rock, W. Va. A 3,000-bbl. benzol acetone dewaxing unit has been erected by The Lummus Co. at the Paulsboro, N. J., refinery of Socony-Vacuum Co.

While no large new refineries have been built in Canada such as have marked the developments of other recent years, several small plants have been built in the western provinces and important additions have been made to existing establishments. British American Oil Co. has constructed a 60,000,000-cu. ft. gasoline absorption plant in the Turner Valley. Comet Oil Refineries at Montreal added a 2,700-bbl. topping plant and a 2,280-bbl. cracking unit and McColl-Frontenac Oil Co. increased the capacity of its Gray clay treating installation. A 900-bbl. Dubbs cracking unit was built by Lloyd Refineries at Pt. Credit, Ontario.

Owing to unsettled conditions confronting the oil industry in Mexico, little activ-

Last piece of rigging equipment, a seven and a half ton steam winch supplied by Pacific Crane and Rigging Company of Los Angeles, swings aboard the Dollar Lines around the world liner, President Coolidge. Part of the 80 tons of refinery equipment being shipped by Pacific Crane and Rigging Company together with the building crew to Bahrein in the Persian Gulf for additions to the refinery of the California-Texas Oil Co., Ltd.



Boiler house in the Herbert Green refinery in England.

ity in the way of refinery construction has taken place in that country but Petromex, the government controlled petroleum company, has added a Dubbs cracking unit of 1,100 bbl. daily capacity to its refinery at Tampico.

In the Dutch West Indies the expansion programs of Curacaosche Petroleum (Royal Dutch Shell) and of Standard Oil Co. of New Jersey at Aruba, which have been under way for the past three years, have been carried further toward completion and have included the addition by the former company of two Dubbs cracking and naphtha reforming units of 8,850 and 8,500 bbl. daily capacity at Curacao and one of 2,200 bbl. at Aruba.

On the continent of South America the year has witnessed the completion of the ANCAP refinery at Montevideo, which is described fully on other pages of this issue. Minor additions to refinery equipment have been made in Argentina, including a 3,200-bbl. Dubbs cracking unit for Shell, and it is reported that the YPF is contemplating the erection of an additional small refinery in the Mendoza field.

Venezuela has indicated that its policy favors the development of a domestic refining industry by including in new concessions a stipulation requiring the construction of refining plants.

A contract was concluded at the end of August between the government of Venezuela and the Socony-Vacuum Company (Standard Oil Co. of New York) for the concession of about 1,500,000 acres for petroleum exploitation, in the states of Monagas, Anzoátegui and Guácrico, eastern and east-central Venezuela, at a price of $2,000,000. Under the contract, the concessionary agrees to construct a large refinery in eastern Venezuela.

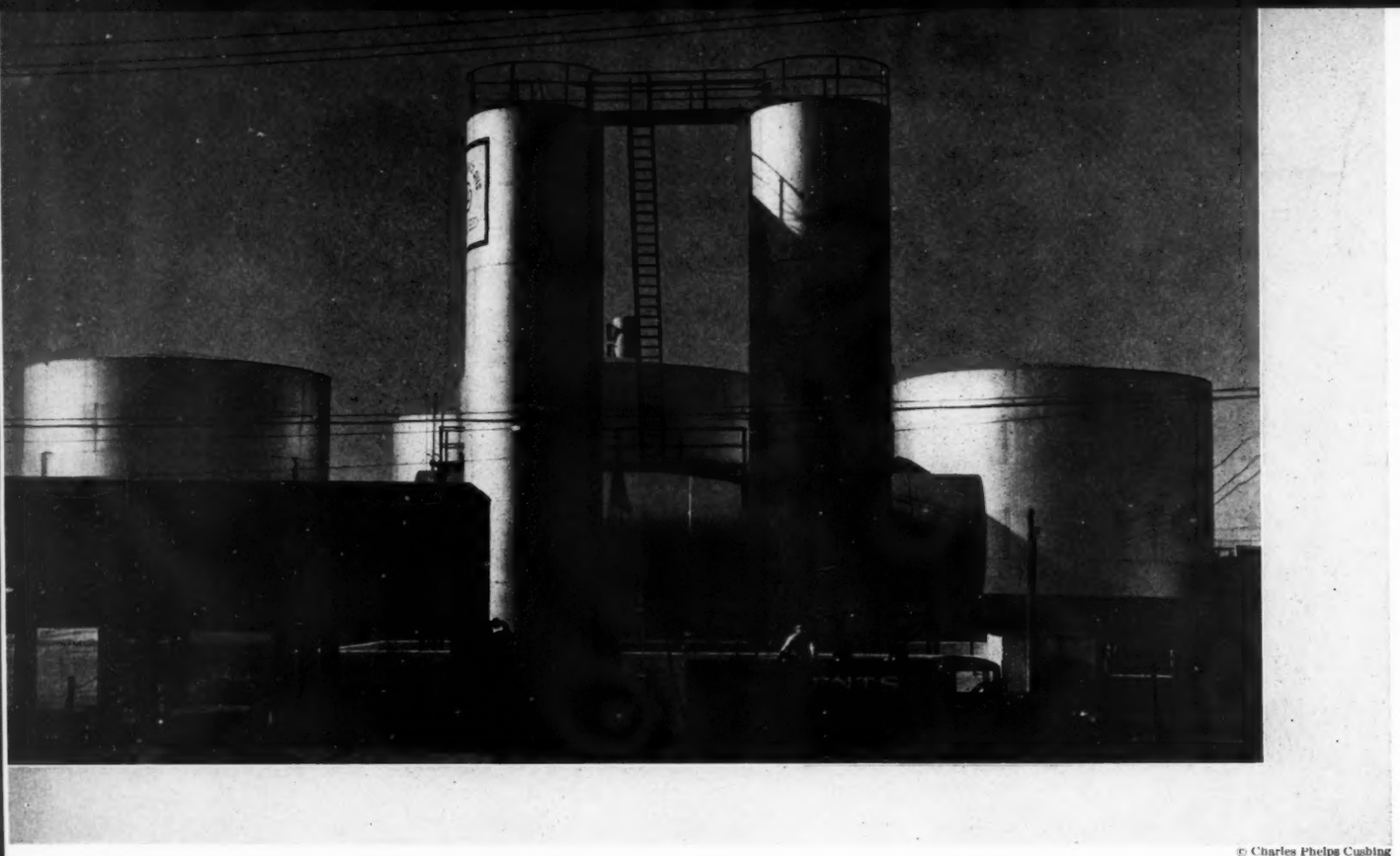
Under a recently closed contract between the government and the Standard Oil Company of Venezuela (Standard of New Jersey interest), that company also agrees to erect a refinery in eastern Venezuela, doubtless in the region of its exploitations in the state of Monagas. Neither of these projects, of course, has as yet approached the stage of construction.

Europe has witnessed an unusual amount of activity during the year, both in the way of additions to existing facilities and in the projection of new plants. Activities in Germany, Roumania and the Soviet Union are dealt with in separate articles, but mention of some of their undertakings may be included here as part of the general picture.

Exceptional interest was attracted by the announcement early in the summer that a new refinery was to be built in the Irish Free State because it involved the granting of a monopoly to the refining company, Irish National Refineries Ltd. Details of the refinery's equipment have not been released but it will be located at Dublin and will produce a complete line of products. T. J. C. Burgess, of London and Thames Haven Oil Wharves, and the Crusader Petroleum Co., organized by W. R. Davis, are leading factors in the company.

Developments in the United Kingdom have included the addition of an 8,570-bbl. atmospheric and vacuum distillation unit to the great Llandarcy plant of Anglo-Iranian Oil Co., construction of a stabilization system and an Edeleanu solvent refining plant for the Agwi Petroleum Co. (Anglo-American) at Fawley, erection by Alco Products Co. of a specialty plant for the Anglo-American Oil Co. at Port Ellesmere, and additions to the existing refinery at London and Thames Haven Oil Wharves under the supervision of Foster Wheeler Ltd.

The important new refinery of Herbert Green & Co. Ltd. at East Halton for the



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production of lubricating oils by the Duosol process is the subject of a special article elsewhere in this issue.

The granting of a refining concession to Compagnie Petrolifere Starnaphtha by the French government provides for the addition of another new plant to the already redundant refining capacity of that country. The new refinery will be located near Marseilles and will operate on Roumanian crude.

Details of its construction have not yet been announced. Other changes in France during the year have been limited to improvements in and additions to existing establishments. Dubbs cracking and reforming units have been installed by S.A. des Petroles Jupiter at Pauillac and Petit Couronne and a 500-bbl. full flashing Dubbs cracking unit has been added to the equipment of Societe Lyonnaise at Auton. Vacuum Oil Co. S.A.F. has completed its solvent treating plant at Gravenchon for the production of Clearasol lubricating oils and it is reported that a new propane dewaxing plant is to be added to the Port Jerome refinery of Standard Franco-Americaine.

In Holland the Royal Dutch-Shell has been engaged in the construction of a refinery at Pernis which includes a 9,000-bbl. daily capacity Dubbs cracking unit. Poland's facilities have been increased by the construction of a Foster Wheeler atmospheric and distillation unit for Galicja Spolka Akcyjna at Drohobycz and by the erection of a refinery at Cracow, also by Foster Wheeler, for Zeilenievski & Fitzner. In Czechoslovakia Fanto Werke A.G. have projected a new cracking unit for installation at Pardubice. At Bratislava a Dubbs cracking unit of 1,100 bbl. daily capacity has been constructed for the Apollo company.

Developments in Germany have been chiefly along the line of establishing coal hydrogenation plants or utilization of the Fischer-Tropsch process, a field which has received the intensive efforts of German technologists during the past few years. Gewerkschaft Deutsche Erdol Raffinerie has installed a Lummus-built, 1,500-bbl. vacuum distillation unit at Deurag. The Deutsche Vacuum Oil A.G. has completed a solvent treating plant at Bremen after designs by Max B. Miller & Co. A discussion of the German refining situation appears on another page.

Italy is another country that has been giving particular attention to hydrogenation under encouragement from the government and numerous plans for hydrogenation plants have been projected. One of these that is well advanced is that of Azienda Nazionale Idrogenazione Carburanti (National Motor Fuel Hydrogenation Co.) for a refinery to operate on Albanian crude. Aquila S.A. Tecnico Industriale has greatly enlarged its Trieste refinery, bringing its capacity to over 10,000 bbl. daily. The work was carried out by Reinmetal Borsig Werke of Dusseldorf, Germany.

Improvements in Roumania have included the installation of a tube still distillation unit, a stabilization system and a phenol solvent process at Ploesti by Romano Americana (Standard Oil of New Jersey). A 2,550-bbl. Dubbs cracking unit has been added to the Campina refinery of Steaua Romana and a 3,450-bbl. Dubbs cracking unit has been installed by Petrol Block.

The Soviet Union's program of refinery expansion has been carried forward during the year by construction of a complete new refinery at Ufa. This is a 12,000-bbl. plant designed and built by Alco Products and includes a two-stage distillation unit, a reforming unit, centrifugal acid treating unit and a doctor treating plant. The plant was designed with particular attention to obtaining maximum flexibility and to withstand the corrosive action of Sterlitmak crude which is of high sulphur content.

In Spain the Compañia Española de Petroles S.A. (CEPSA) has undertaken

(Continued on page 559)

Abadan

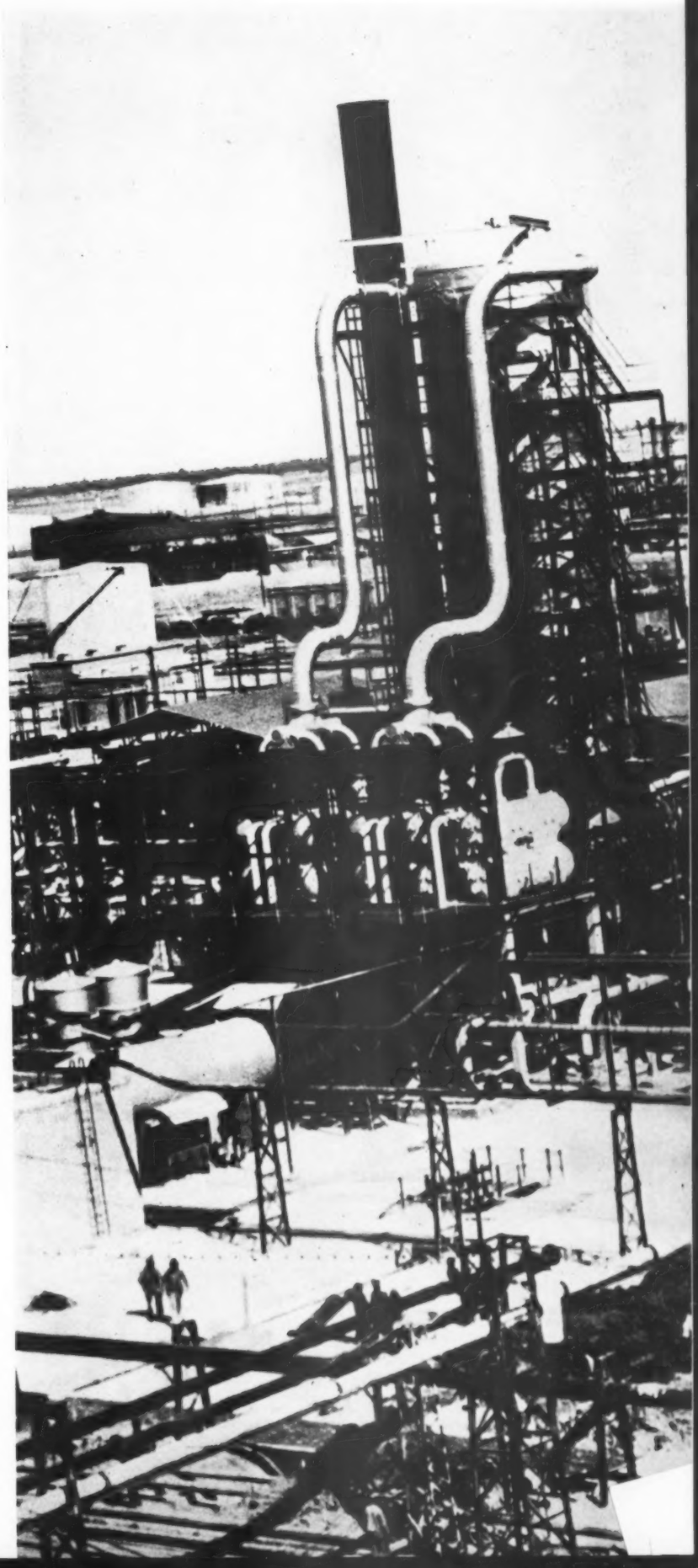
World's Largest Refinery

THE largest oil port in Asia is situated on a small island in the Shatt-el-Arab (the merged Tigris and Euphrates) a short distance from the confluence of this river with the waters of the Persian Gulf. Not many years ago this island of Abadan, like most of the hundred or more miles of hinterland, was flat alluvial desert, burnt and arid during the hot summer months, though sufficiently fertile along the river banks to maintain a small population engaged in the simpler forms of agriculture and living much the same life as did their ancestors when Nebuchadnezzar ruled in Babylon. The desert is still the desert, but now a thin Y-shaped black line has been drawn on its surface, the lower extremity terminating at Abadan Island and the upper extremities in the mountains which rise sharply from the desert plain 130 miles from the coast. Along this thin black line flow some 7,000,000 Imperial gallons (200,000 bbl.) of crude oil each day from the two inland oil fields at Masjid-i-Suleiman and Haft Kel to the great industrial town which has come into being on Abadan island.

Petroleum refining is one of the oldest and one of the newest industries of Iran and Iraq, for petroleum bitumen was used in the building of Ur, while the refinery at Abadan, not many miles from Ur, came into existence only 25 years ago and has been entirely reconstructed and greatly enlarged during the past few years.

About 80 percent of the crude oil received from the pipeline is distilled at Abadan, the remainder being sent by tanker to the Anglo-Iranian Oil Company's refineries in Europe and in Australia.

The total crude oil distillation capacity at Abadan is approximately 270,000 bbl. (10,000,000 Imperial gallons) per day. All the units are of modern construction, consisting of the normal pipe still and fractionating columns and at least half the capacity is in the form of combined topping and vacuum distilling units, the



remainder being straightforward topping units. The latest two additions to the crude oil benches are of interest on account of their unusual size, for they are at present the largest of their class in the world. Each of these units has a normal input capacity of 65,000 bbl. (2,250,000 gallons) of crude oil per day, and is capable of producing the full range of petroleum products from gasoline to pitch.

In addition to the crude oil stills there are also some 35,000 bbl. per day of redistillation units for the production of special products as well as the distillation plant associated with the cracking section of the refinery for re-running the treated pressure distillate.

All distillation units are connected to a comprehensive gas-collecting system which conducts the gas to a central compression and absorption plant. The gasoline thus recovered is stabilized, the stable gasoline being blended back with various grades of gasoline distillates as specifications demand. Much of the stripped gas is at present used as fuel, but in the near future processes will be brought into operation for the conversion of uncondensed gases to stable liquid products.

Since Iranian crude oil is of the paraffin-base type the straight-run naphtha is naturally of a low octane rating, while the heavier fractions contain an undesirably high proportion of wax. In consequence, cracking plays a very important role in the refining of this crude into products of the high standards of quality set by modern market requirements. The cracking equipment at present installed has an input capacity of 90,000 bbl. per day. The eight "low pressure" units erected in 1930 are Cross-Kellogg plants operating at pressures up to 300 lbs. and are employed partly on naphtha reforming for the production of high octane motor spirit and partly on cracking a wax-bearing distillate in order to produce the maximum amount of wax-free gas oil for fuel purposes. During 1936 the further installation of four high-pressure naphtha reforming units, each of 15,000 bbl. per day input operating at 750 lbs. pressure and embodying all the most modern improvements for efficiency and flexibility, has more than doubled the cracking capacity of the refinery. Each pair of units possesses its own stabilizer, while the five distillation units for re-running the stabilized cracked spirit after its chemical refining treatment, the absorption plant and other equipment subsidiary to the cracking operation, are also located in the cracking area of the refinery.

The main refinery products consist of various grades of straight-run and cracked gasoline (defined by boiling range, vapor pressure and octane number), kerosene, gas oil, light and heavy residuum fuel oils and blends of gas oil and residuum to meet certain commercial specifications. A considerable proportion of the fuel oil is reserved for the use of H.M. Navy, while the production of specially blended aviation gasoline is a matter of steadily increasing importance in view of the developments in air transport, but the stable products are motor gasoline, kerosene, gas oil and bunker fuel oil, the first two of which, of course, require chemical refining treatment to bring them up to market specifications of quality. It is particularly notable in this connection that the high efficiency in design of the very modern distillation units is reflected not only in superior economy in distillation costs, but in superior purity of the distillates and consequent reduction in the cost of subsequent treatment.

The treatments given depend, of course, on the type of distillate. Straight-run gasoline or benzine is soda-washed at once to remove hydrogen sulphide, thus preventing the formation of corrosive elemental sulphur by oxidation. Since it contains a small amount of mercaptans it may then be sweetened by agitation with sodium plumbite in a continuous washery, the plumbite being regenerated by air in the standard manner. Desulphurization is not as a rule required, but when necessary it is effected by a calcium hypochlorite treatment in a washery of the pressure orifice type, the capacity of which is 1,500,000 gallons per day.

As has been stated previously, most of the straight-run naphtha is reformed by cracking in order to raise the octane value. In order to reduce corrosion of the cracking plant all naphtha to be cracked is given a preliminary soda wash in an orifice type system which has a capacity of 3,000,000 gallons per day.

The cracked spirit (pressure distillate) is rendered colorless and gum-stable by a very light sulphuric acid treatment carried out in that most efficient form of continuous counter-current plant, the Holley-Mott washer, the treated spirit then being soda-washed and redistilled at a low temperature in order to minimize corrosion and to give a distillate with a very low gum number.

This distillate is finally refined by a soda and hypochlorite treatment, the washer again being employed. This washer has a capacity of 2,500,000 gallons per day.

Kerosene is refined by the Edeleanu method with liquid sulphur dioxide, the plant being capable of handling 800,000 gallons per day. The extract is rich in aromatic hydrocarbons and after fractionation and refining is a valuable source of anti-knock material for addition to motor spirit and to tractor vaporizing oil, respectively.

The kerosene, after SO_2-refining, is finally sweetened by a plumbite treatment to eliminate mercaptans, thus rendering the oil stable in storage and of a good odor.

Gas oil is normally free from hydrogen sulphide and napththenic acids and consequently requires no treatment, but facilities for soda-washing are available if necessary.

Refining treatments on the scale outlined above require the services of chemical plant of some magnitude for the production of the necessary chemicals. For example, for the manufacture of the sulphuric acid required, two plants, each capable of producing 30 tons per day of acid, have been installed, while the Edeleanu plant is equipped with its own source of SO_2 which may be made either from sulphur or, alternatively, from hydrogen sulphide extracted from the crude oil, purified, compressed and stored as liquid for make-up and reserve.

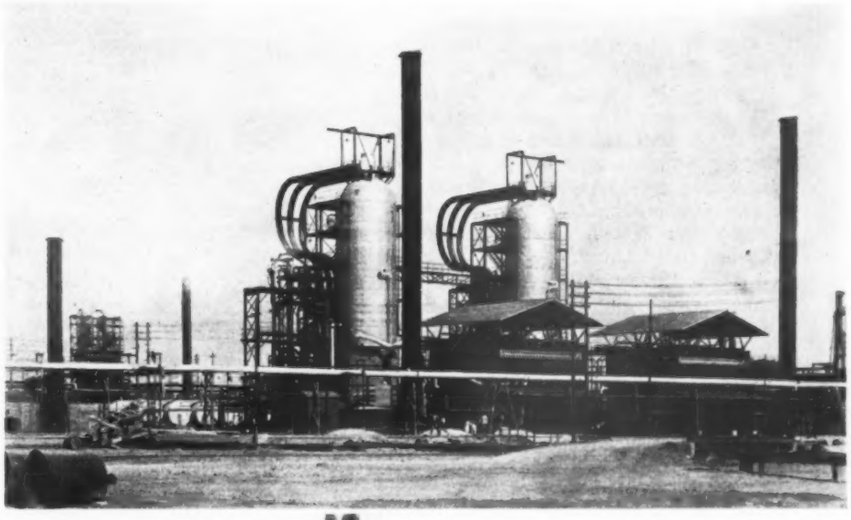
Lime is manufactured from local shell deposits which constitute a very pure form of calcium carbonate, while a 4-ton per day hydrochloric acid plant supplies acid for the treatment of the wells in the oil-fields.

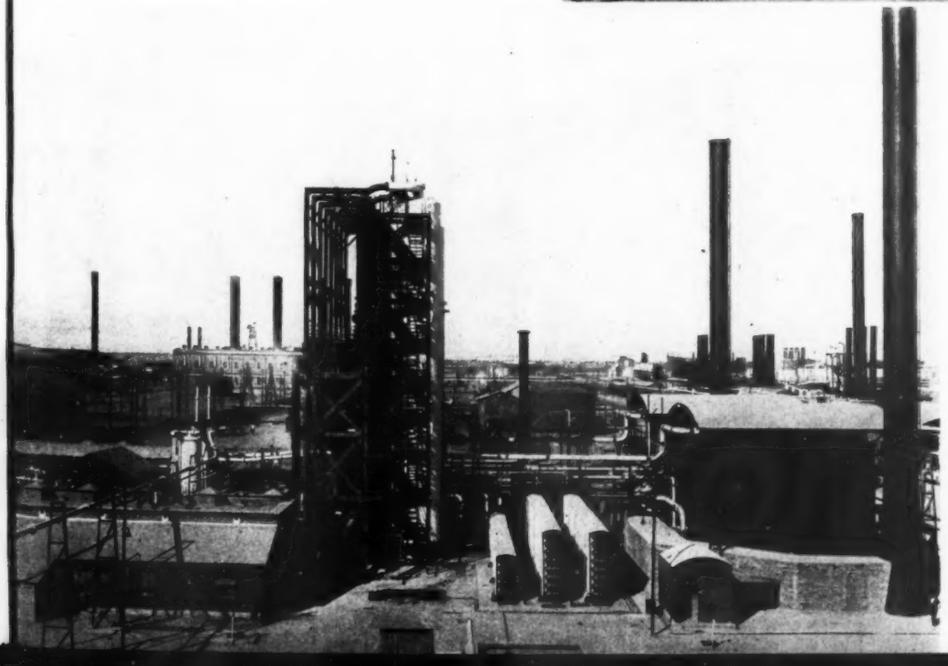
Space does not permit detailed enumeration of the many vital and extensive internal services necessary for the operation of an undertaking of this magnitude; one can only make a passing reference to the 24,000 kilowatt power house, the pumping equipment for the circulation of 200,000,000 gallons of water per day, the recently reconstructed and greatly enlarged chemical laboratories which maintain an unceasing control on the operation and out-put of the refinery units, the still more extensive engineering work-shops responsible for the erection and maintenance of all refinery plant and equipment, and the transport department which handles both surface and air movements of personnel and material.

Our account of Abadan has so far been confined to the refinery area. A brief reference is also due, however, to other sections of the Abadan establishment which play an equally important part in its efficient and successful operation, and which have needed equal care in planning and construction. There are, for example, the great storage tank areas which provide capacity for 2,500,000 tons of crude oil and finished products, as well as the smaller refinery working tanks and some special pressure tanks for storage of butane and natural gasoline. There is the long line of loading jetties where the 10,000-ton tankers of the British Tanker Company (the shipping organization of the Anglo-Iranian Oil Company) come and go, often at the rate of 10 or more per week, their journeys amounting to an aggregate of 6,000,000 miles per annum.

There are also the great residential areas outside the refinery area where the 600 Europeans and the 10,000 Iranians on the refinery staff are housed. These have been laid out in such a way as to render living conditions as comfortable and pleasant as possible in a climate which is at times somewhat trying, and the tree-lined streets and brightness of the bungalow gardens afford a refreshing contrast to the desert outside. Excellent provision for leisure hours is afforded by the clubs with their libraries, cinemas, swimming pools and various sporting and other activities which play so important a part in the social life of a somewhat isolated community.

The rapid and successful development of so great an undertaking as Abadan, under geographical conditions not of the easiest, may fairly be regarded as an example of modern industry at its best—the product of careful planning, the fullest utilization of scientific progress in engineering and chemistry, and effective co-ordination of the numerous sectional activities to a common purpose.





On the facing page is shown the cracking area of the Anglo-Iranian's Abadan refinery: above a 12,000 bbl. per day vacuum distillation unit at this plant and at left, a 30,000 bbl. per day crude oil distillation unit.

N. N. C. Type Cracking in Japan

By Morio Otaki

A NOTEWORTHY development in the Japanese oil refining industry has been the recent attempt on the part of the domestic refiners to expand their refining facilities, due principally to the operation of the Petroleum Business Law since 1934.

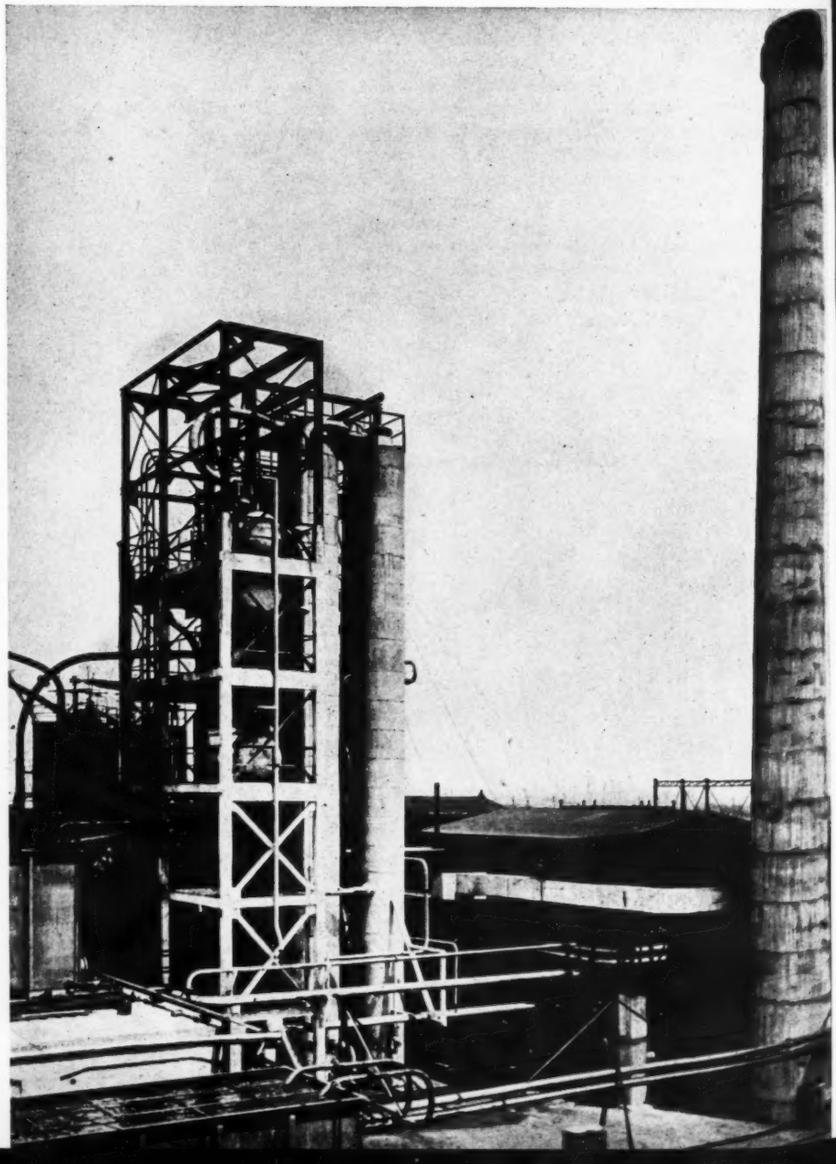
The majority of domestic companies either planned expansion of their refineries or prepared for construction of gasoline plants. The Ogura Oil Company was the first to enlarge its refining facilities during 1935, while the Japan Oil Company, the Mitsubishi Oil Company, the Hayayama Oil Company and the Aikoku Oil Company have almost half completed their expansion programs during the first six months of 1936.

Cracking units are more or less an innovation in this country. The Dubbs-type cracking plant built by the Japan Oil Company at its Tsurumi refinery in 1924 was perhaps the first cracking plant ever constructed in Japan.

During the ensuing 12 years, refinining technique in Japan's oil industry has made remarkable progress. One of the outstanding achievements in this connection is the invention of the N. N. C. type cracking plants by engineers of the Japan Oil Company. This type of cracking unit was constructed in the Tsurumi refinery of the Japan Oil Company, and has been in operation since May, 1935.

With a daily cracking capacity of 1,500 bbl., this plant is capable of yielding 45 percent gasoline under 400-pound cracking pressure. It is of the non-reaction chamber type.

Cracking methods practiced in Japan in the past, such as the Dubbs-type, the Cross-type, etc., required spacious reaction chambers to keep the oil at high temperatures. That served to cause the formation of coke and pitch, and consequently hampered continuous operation of the plant. The necessity of spacious reaction chambers also involved higher construction costs, while exposing a large quantity of oil to high heat and pressure invited many dangers. An American named Donnelly obtained the first patent for this type of the cracking plant in Japan in 1925, but it was not widely used by the Japanese companies. The N. N. C. type cracking plant in the Tsurumi refinery, near Tokyo, has a monthly feed capacity of 5,000 kilolitres, and uses heavy oil as material. The heavy oil itself, however, does not serve directly as material. Material oil to be cracked is heated first in the cracking furnace and then is led to the reaction furnace at 500-pound pressure for cracking reaction. The feeding of heavy oil, the new material oil, takes place when the cracked material oil comes out of the reaction furnace. This process serves to lower the temperature of the material oil and to check the danger of subjecting it to high temperatures for a long time. The pressure in the reaction furnace is regulated by the reducing valve attached to the end of the furnace. From the reducing valve, the material oil proceeds to the first evaporating tower, where it is divided into light oil and heavy oil. The light oil then flows into the rectifying column to be fractionated into cracked gasoline, light oil and return stock. The heavy oil which stays in the first evaporating tower proceeds to the second evaporating tower, and is again separated into light oil and heavy oil. The return stock produced from the light oil is used partly



New type N. N. C. gasoline plant at the Tsurumi Refinery of the Japan Oil Company in Kanagawa Prefecture.

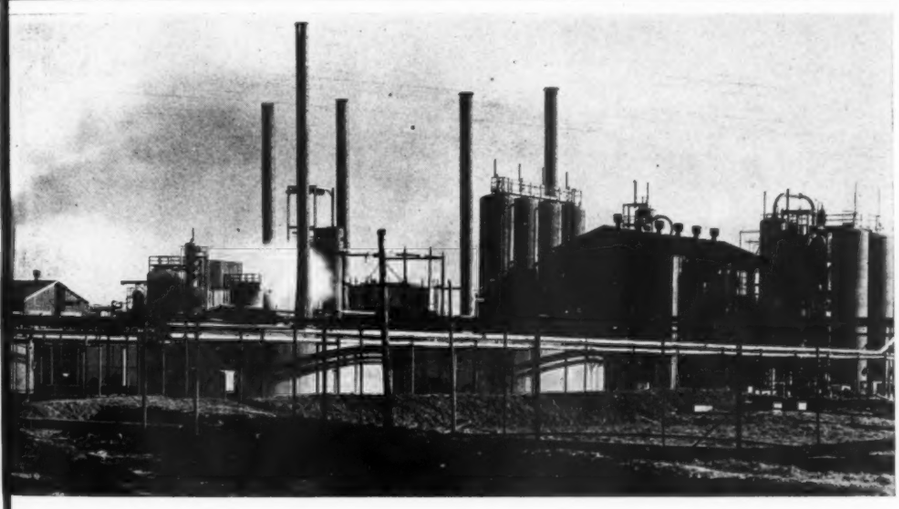
for cracking and partly as fuel. The N. N. C. plant in the Tsurumi refinery has been working excellently since erection a year or so ago. It is capable of operating 20 consecutive days or more a month. This enables the plant to utilize waste heat and thus save gasoline redistillation expenses. The plant yields 35–45 percent gasoline (dry-point 220 deg. C.), 50 percent heavy oil, and about 2 percent gas. Gasoline produced by this plant is of superior quality, and is accompanied by very little odor. That this type of plant requires smaller amounts of refining chemicals is another special feature. The Chosen Oil Company, a semi-governmental organization, plans to install an N. N. C. cracking plant at its new refinery, scheduled to start operation by the end of this year. A photograph showing details of the N. N. C. cracking plant is reproduced elsewhere in this article.

The Badger-type pipe still recently installed in the refinery of the Yoshida Oil Company in Osaka is one of the smallest of this kind, handling only 500 bbl. a day. Pipe stills of this size are steadily coming to be widely used in this country.

Cracking units generally used by the important refiners are principally American, including the Cross, Jenkins, and Foster-Wheeler pipe stills, the Schwalz and the Kellogg Lube-units. Units used by leading refining companies are shown in the accompanying table.

The N. N. C. unit is perhaps the only Japanese-made cracking plant. It is used exclusively by the Japan Oil Company. The majority of important Japanese refineries are topping or cracking plants, mostly combinations of the two. As yet very few refineries are equipped with complete skimming plants.

According to figures obtained from the Ministry of Commerce and Industry, there were 77 refineries, including several gasoline plants, in Japan proper and Hokkaido, at the end of January, 1936. Niigata prefecture had 36 refineries or 46.7 percent of all those in Japan. The accompanying table shows the distribution by prefectures of these refineries.



Rundown tanks in a British lubricating oil refinery.

Carbon residue test in the Esso Laboratories at Bayway, N. J.

Types of Units Used By Leading Japanese Refiners

Type of unit	Company
Cross	Mitsubishi Oil
	Ogura Oil
	Japan Oil
Jenkins	Ogura Oil
Foster-Wheeler Pipe stills	Japan Oil
Schwalz	Hayayama Oil
Kellogg Lube-units	Ogura Oil
N. N. C.	Japan Oil

Principal Petroleum Importers in Japan

Importer	*Address*
Tokyo Prefecture (8)	
Kojiro Matsukata	Eighth Floor, Marunouchi Bldg., Marunouchi, Tokyo City
Mitsubishi Shoji K. K.	2–4 Marunouchi, Tokyo City
Mitsui Bussan K. K.	2–1 Muromachi, Nihonbashi, Tokyo
Japan Tanker Company, Ltd.	3–6 Marunouchi, Tokyo City
Adzuma Steel Works	Care of Kimura Shoten, 1–12, Kobikicho, Kyobashi, Tokyo City
*Japan Oil Company, Ltd.	3–4 Marunouchi, Tokyo City
*Asahi Oil Company, Ltd.	1–6 Marunouchi, Tokyo City
Nomura & Company	Eighth Floor, Marunouchi Bldg., Marunouchi, Tokyo City
Kanagawa Prefecture (3)	
*Yosaburo Hayayama	46 Ohgimachi, Kawasaki City
Rising Sun Petroleum Company	58 Yamashitacho, Nakaku, Yokohama City
Standard-Vacuum Oil Company	2 Yamashitacho, Nakaku, Yokohama City
Osaka Prefecture (3)	
*Osaka Mineral Oils Refining Co., Ltd.	Funamachi, Taishoku, Osaka City
Doi Petroleum Company, Ltd.	2–27 Fukumachi, Taishoku, Osaka
Japan-America Mineral Oils, Ltd.	6–13 Dotonboridori, Nishiku, Osaka
Nagasaki Prefecture (1)	
Godo Oil Sales Company, Ltd.	48 Uragotomachi, Nagasaki City
Fukuoka Prefecture (1)	
Namico Marukawa	6–28 Higashidorimachi, Moji City
Yamaguchi Prefecture (1)	
Nihon Gyomo-Sengu Company, Ltd.	32 Misakimachi, Shimonoseki City
TOTAL	17

*Refiners.

Petroleum Refineries in Japan

Refinery	*Company*	*Location*
Niigata Prefecture		
Japan Oil Kashiwazaki Refinery	Japan Oil Company	Kashiwazaki
Japan Oil Niigata Refinery	Japan Oil Company	Niigata City
Takamachi Gasoline Plant	Japan Oil Company	Kariha-mura
Nagamine Gasoline Plant	Japan Oil Company	Nida-mura
Ohmo Gasoline Plant	Japan Oil Company	Ohmo-mura
Higashiyama Gasoline Plant	Japan Oil Company	Yamamoto-mura
Maki Gasoline Plant	Japan Oil Company	Maki-mura
Hayayama Niigata Refinery	Hayayama Oil Company	Sekiya, Niigata City
Torigoye Refinery	Japan Oil Mining Co.	Wakinomachi-mura
Nadachi Refinery	Japan Oil Mining Co.	Nadachi-mura
Niitsu Refinery	Tsunekichi Niitsu	Yamanoshita, Niigata City
Niitsu Refinery (2nd)	Tsunekichi Niitsu	Yamanoshita, Niigata City
Nishinakadori branch, Niitsu Refinery	Tsunekichi Niitsu	Nishinakadori-mura
Saito Refinery	Eizo Saito	Sekiya, Niigata City
Wada Refinery	Kiichiro Wada	Sekiya, Niigata City
Asada Refinery	Tsunegoro Asada	Sekiya, Niigata City
Hara Refinery	Masakichi Hara	Numatare, Niigata City
Yamagishi Refinery	Yamagishi & Company	Numatare, Niigata City
Yamasu-Suzuki Refinery	Ukichi Suzuki	Nakajima-machi, Nagaoka City
Washio Refinery	Washio & Company	Kita Nakajima-machi, Nagaoka City
Kato Refinery	Kato & Company	Nagaoka City
Kato-Niitsu Refinery	Seiichi Kato	Niitsu
Kobayashi Refinery	Kobayashi & Company	Fukuro-machi, Nagaoka City
Marudai-Terai Refinery	Toraichiro Terai	Nagaoka City
Okuda Refinery	Seiji Okuda	Niitsu
Ishizaki Refinery	Ishizaki Refinery, Ltd.	Niitsu
Ohtani Refinery	Tatsuji Ohtani	Niitsu
Shimidzu Refinery	Jisaburo Shimidzu	Itakura-machi
Matsubashi Refinery	Yoshiji Matsubashi	Itakura-machi
Ohya Refinery	Tsunekichi Ohya	Idzumozaki-machi
Matsumura Refinery	Tsurumatsu Matsumura	Idzumozaki-machi
Matsunoyama Oil Refinery	Irini & Company	Matsunoyama-mura
Komi Refinery	Kikuzo Komi	Sugawara-mura
Kariha Gasoline Plant	Nakano Mining Company	Kariha-mura
Betsuyama Gasoline Plant	Nakano Mining Company	Naigo-mura
Kokura-Kamata Refinery	Ogura Oil Company	Naigo-mura
Total		36
Akita Prefecture		
Japan Oil-Akita Refinery	Japan Oil Company	Tsuchizaki
Yuri Gasoline Plant	Japan Oil Company	Michikawa-mura, Yuri
Hirasawa Plant, Niitsu Refinery	Tsunekichi Niitsu	Hirasawa-machi
Hirasawa Refinery	Hirasawa Refinery, Ltd.	Hirasawa-machi
Nagai Refinery	Kintaro Nagai	Iidagawa-mura
Okubo Refinery	Morohashi & Company	Iidagawa-mura
Futuda Refinery	Morohashi & Company	Tenno-mura
Hibiki Refinery, Kaneko Oil Company	Matsuyo Kaneko	Hibiki-mura
Omonogawa Refinery	Japan Mining Company	Terauchi-mura
Total		9
Kanagawa Prefecture		
Mitsubishi-Kawasaki Refinery	Mitsubishi Oil Company	Kawasaki City
Toyo-Yokohama Refinery	Toyo Petroleum Company	Tsurumi-ku, Yokohama City
Tamiya-Tsurumi Refinery	Tamiya & Company	Tsurumi-ku, Yokohama City
Toho-Yokohama Refinery	Toho Oil Company	Tsurumi-ku, Yokohama City
Kokura-Yokohama Refinery	Ogura Oil Company	Kanagawa-ku, Yokohama City
Japan Oil-Tsurumi Refinery	Japan Oil Company	Tsurumi-ku, Yokohama City
Hayayama-Kawasaki Refinery	Hayayama Oil Company	Kawasaki City
Aikoku-Kawasaki Refinery	Aikoku Oil Company	Kawasaki City
Total		8
Tokyo Prefecture		
Edogawa Refinery	Edogawa Oil Company	Edogawa-ku
Kokura-Tokyo Refinery	Ogura Oil Company	Joto-ku
Asahi-Tokyo Refinery	Asahi Oil Company	Joto-ku
Total		3
Shidzuoka Prefecture		
Fuse Refinery	Shinsuke Fuse	Sagara-machi
Aichi Prefecture		
Ushida Refinery	Ushida Oil Company	Shinkawa-machi
Wakayama Prefecture		
Kainan Refinery	Nankai Oil Company	Kainan City
Osaka Prefecture		
Maruzen-Osaka Refinery	Maruzen Oil Company	Taisho-ku
Toyo-Osaka Refinery	Toyo Oil Company	Taisho-ku
Osaka Mining Refinery	Osaka Mineral Oil Refinery, Ltd.	Taisho-ku
Total		3
Hyogo Prefecture		
Mikado-Akashi Refinery	Mikado Oil Company	Akashi-gori
Yamaguchi Prefecture		
Nihon Hatsudokiyu Refinery	Japan Motor Oil Company	Ube City
Japan Oil-Shitamatsu Refinery	Japan Oil Company	Shitamatsu-machi
Asahi-Hikojima Refinery	Asahi Oil Company	Shimonoseki City
Total		3
Ehime Prefecture		
Aoki Refinery	Aoki Oil Company	Yawatahama-machi
Matsuoka Refinery	Tomitaro Matsuoka	Matsuyama City
Takeda Refinery	Fukutaro Takeda	Kamiyama-machi
Total		3
Fukuoka Prefecture		
Kyushu Refinery	Kyushu Refinery, Ltd.	Tobata City
Takahashi Refinery	Takahashi Oil Industrial Company	Moji City
Total		2
Nagasaki Prefecture		
Fuji Refinery	Fuji Oil Transportation Company	Sasebo City
Chiba Prefecture		
Kitamura Refinery	Kitamura Oil Company	Choshi City
Hokkaido		
Hokkaido Refinery	Japan Oil Company	Sapporo City
Atsuma Gasoline Plant	Japan Oil Company	Atsuma-mura
Ishikari Gasoline Plant	Japan Oil Company	Ishikari-machi
Hayakita Refinery	Japan Petroleum Mining Company	Yasuhira-mura
Total		4
GRAND TOTAL		77

Engineering Refineries for Four Continents

From Japan to California refiners employ Lummus equipment for distillation, combination cracking, solvent extraction, dewaxing of lubricating oils, and asphalt manufacture.

A VERY significant point to be noted in the recent development in petroleum refining technique has been the tendency to separate the crude into either fractions closely approximating pure organic compounds or, at worst, groups of compounds of closely related chemical constituents. In many cases this may be augmented by adding elements not usually found in petroleum hydrocarbon, such as chlorine, and oxygen, to produce derivatives entirely foreign to the original material. In other cases, the arrangement of the hydrogen and carbon is so modified as to produce yields of desirable components many times greater than would otherwise be obtained. A classic example of this type of operation is the production of iso-octane, a substantially pure compound which is produced by hydrogenating the butanes to butylenes, polymerizing the butylenes and hydrogenating the resulting polymers to iso-octane, a superior fuel for automobiles and aeroplanes.

The use of a host of solvents among which may be mentioned furfural, acetone, methyl-ethyl-ketone, phenol and cresylic acid, for separating the crude lubricating oil fractions into "paraffins" and "naphthenes" illustrates the use of a variety of new chemicals for separating petroleum fractions into lubricants of superior quality. It would appear that the petroleum industry is headed towards a closer alliance with the chemical fields as shown by new projects under development in the laboratories of the refiners and engineering companies.

The Lummus Company's forty years experience in the chemical fields together with its accomplishments in the more orthodox branches of petroleum refining, place it in a unique position during this transition period. The Lummus Company's designs reflect the application of advanced chemical engineering practice tempered with practical considerations born of years of experience in designing equipment for petroleum refineries throughout the world. Some recent Lummus designs of general interest will be briefly described.

The advantages of combination cracking units, in which operations of crude distillation, viscosity breaking, reforming, segregation and cracking of gas oil fractions are carried on concurrently, are too well-known to require detailed discussion.

Pure Oil Company's combination topping and cracking plant recently completed at Toledo, Ohio: engineered and constructed by the Lummus Company.

20 LUMMUS

GULF OIL CORPORATION — 5,000 barrels per day Furfural unit, Port Arthur, Texas. The unit is sufficiently flexible to produce high viscosity index specification raffinate products from feed stocks of widely varying characteristics.

GULF OIL CORPORATION — Naphtha rerun unit of unusual flexibility and efficiency . . . processing four different acid treated distillates at the rate of 3,600 barrels per day . . . producing an overhead cut . . . four side streams . . . and bottoms—all meeting special specifications.

SHELL PETROLEUM CORPORATION, Wood River, Illinois — The refiner desired to run 6,300 barrels per day of 25 deg. API gravity Mid-Continent crude, taking overhead 33 volume per cent on the charge. It was further stipulated that the bottoms from the unit should have a 400 deg. F. close cup flash and not over 5% boiling at 400 deg. F. under 10 mm. vacuum. To meet these requirements Lummus supplied a novel vacuum fractionating unit employing shower decks instead of the conventional bubble cap. With this design it was possible to minimize the pressure drop between flash zone and tower top and thus obtain the desired results.

SHELL PETROLEUM CORPORATION, Houston, Texas — The modernization of existing topping equipment and the construction of additions to provide 25,000 barrels per day of crude . . . fully guaranteeing the yields and product quality on three different crudes.

SHELL-MEX. AND B. P., LTD., Thames Haven, Essex, England — A 1,170 barrel per day Benzol Acetone Dewaxing Plant designed to operate on Conception solvent treated distillate.

GEWERKSCHAFT DEUTSCHE ERDOL RAFFINERIE, Hanover, Germany—Now under construction . . . a new lubricating oil refinery combining the most modern unit processes for lubricating oil production—Coubrough Vacuum Distillation, Furfural Solvent Refining, Clay Contacting and Benzol Acetone Dewaxing. Capacity: 1,600 barrels per day, 70% Nienhagen Reduced Crude.

SOCONY-VACUUM OIL CO., INC., Paulsboro, N. J. — The largest benzol acetone plant constructed to date, designed to process six different feed stocks on average thruput of 3,190 barrels per day to produce zero pour test dewaxed oil. By adding filter surface, the capacity of the plant can be increased to 3,690 barrels per day.

SOCONY-VACUUM OIL CO., INC., Olean, N. Y. — A Benzol Acetone Dewaxing plant with a capacity of 1,428 barrels per day of Pennsylvania special wax distillates. With additional filter surface this capacity can be increased to 2,856 barrels per day.

THE PURE OIL COMPANY, Toledo, Ohio — A combination topping and cracking unit in which the various cracking cuts are segregated and separately cracked under optimum conditions. No soakers or reaction chambers are employed. Capacity, 8,000 barrels per day or 5,550 barrels per day of Mt. Pleasant, Michigan crude, the capacity depending upon the products required.

THE PURE OIL COMPANY, Nederland, Texas — Specifications called for a 10,500 barrel per day topping unit to handle three different crudes: East Texas, Van Zandt and Bosco, producing rubber solvent, VM and P Naphtha, Stoddard solvent, kerosene, gas oil and power oil to market specifications . . . a unit of optimum flexibility and fractionating efficiency.

THE PURE OIL COMPANY, Nederland, Texas — A Lummus combination cracking unit with a capacity of 11,100 or 14,000 barrels per day Van Zandt crudes, depending upon the products required. Efficient segregation of charging stocks to separate cracking furnaces assures full advantage of the higher yields obtained.

DEUTSCHE VACUUM OEL A.G., Bremen, Germany — A Benzol Acetone Dewaxing plant incorporating the successful adaptation of the continuous vacuum filter to benzol acetone dewaxing. The plant has a capacity for dewaxing 525 barrels per day of Haenigsen Duosol Raffinate to a zero pour test product.

INSTALLATIONS

EACH ONE TAILORED TO MEET SPECIFIC REFINERY NEEDS

With the expansion of the petroleum industry and the development of new processes, the special requirements of refiners become more and more diversified and exacting. For maximum results each plant must be virtually a tailor-made job—designed to fit processes and conditions.

In the short space of eighteen months Lummus, in addition to other construction, has cooperated with refiners in solving specific problems encountered in the design and construction of the twenty plants summarized on these pages:

RAFFINERIA di NAPOLI, S. A. I., Naples, Italy — Now under construction . . . a 525 barrel per day Benzol Acetone Dewaxing plant designed to operate on a wide range of Duosol refined stocks from Oklahoma City and Coastal crudes.

WHITE STAR REFINERY, Trenton, Michigan — Modification of an existing cracking unit to operate as a combination unit with a capacity of 6,000 barrels per day. The guarantee of 62% yield of 400 end point, 63 octane number gasoline was met successfully with satisfactory length of run.

HERBERT GREEN & COMPANY, LTD., East Halton, England — A complete lubricating plant combining Duosol treating, clay contacting, Benzol Acetone Dewaxing and vacuum lube fractionation. Designed, constructed and operated initially by Lummus. This plant has operated at well over its rated capacity of 1,400 barrels per day, Oklahoma City reduced crude and has produced finished oils of over 100 viscosity index. This benzol acetone dewaxing plant was the first solvent dewaxing plant to be put into operation in Europe.

ASANO BUSSAN CO., LTD., Tokyo, Japan — A 1,000 barrel per day Coubrough unit running Poza Creek Crude to overhead cylinder stock, transformer oil, gas oil, neutrals and 50 Pen. asphalt.

BARBER ASPHALT COMPANY, Maurer, N. J. — A Lummus vacuum pipe still which performs the difficult task of running 6,000 barrels per day of 60% reduced Venezuelian Crude to a 260 deg. F. Ring and Ball melting point (0 penetration) asphalt bottoms.

MAGNOLIA PETROLEUM COMPANY, Beaumont, Texas — Benzol Acetone Dewaxing plant designed to operate on various Oklahoma City or East Texas solvent refined distillates to produce O° F. pour oils. Capacity ranges from 3,060 to 3,415 barrels per day, depending upon the charge stock.

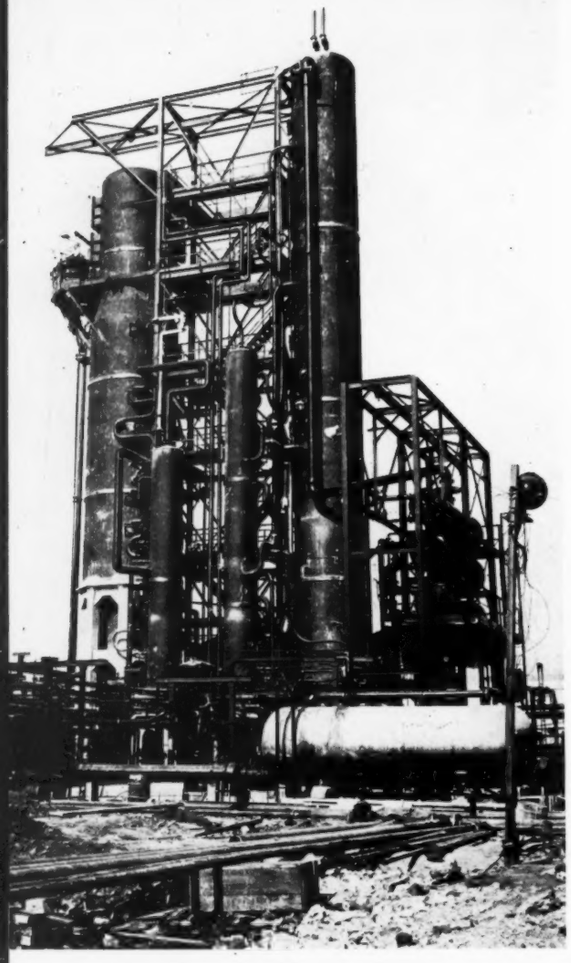
MAGNOLIA PETROLEUM COMPANY, Beaumont, Texas — A large Furfural refining unit capable of handling a wide variety of charging stocks of approximately 3,000 barrels per day to produce raffinates meeting V. I. and color stability specifications after dewaxing.

STANDARD OIL COMPANY OF NEW JERSEY, Campana, Argentina — Atmospheric and vacuum pipe stills . . . designed, constructed and put into initial operation by Lummus, meeting an extremely short delivery date . . . Capacity 6,500 barrels per day, running San Pedro or low cold test Peruvian Crude to produce light and heavy naphtha, refined oil, tractor oil, gas oil, light and heavy lube distillate and bottoms, to rigid specifications.

THE LUMMUS COMPANY, 50 CHURCH STREET, NEW YORK, N. Y. • BUSH HOUSE, ALDWYCH, LONDON, W. C. 2

LUMMUS

PETROLEUM REFINING PLANTS



Combination atmospheric and vacuum distillation units of the Cia. Nacional de Petroleos (S. O. N. J.) at Campana, Argentina.

It will suffice to say that operations of this character result in high yields of superior anti-knock gasoline with a minimum expenditure on labor, fuel and the coincident production of highly unsaturated gases well-suited to subsequent polymerization operations and fuel oil with the minimum cold test and viscosity.

A unit of this type, designed and erected by the Lummus Company, is now completed for the Pure Oil Company, at Toledo, Ohio. This unit has a charging capacity of 8,000 bbl. per day of Michigan crude. The design is such that the unit may operate to produce gasoline and fuel oil or, as an alternate, gasoline, kerosene, furnace oil, and fuel oil, depending upon market requirements. The crude oil is preheated by means of exchangers utilizing heat which would normally be lost in the cracking operation, fractionated to produce a light straight run gasoline (whose octane number is sufficiently high so that reforming is unnecessary), naphtha, kerosene, and furnace oil, if these two latter products are required.

The topped crude is then viscosity broken at 875 deg. F. under 200 lbs. pressure to produce suitable charging stock for the gas oil cracking coil. The virgin naphtha is reformed, the cracked products from this and the gas oil cracking being combined and fractionated in a high pressure fractionation column into gasoline, cycle stock and fuel oil. The gasoline is stabilized in a unit built integral with the cracking unit. In spite of the very paraffinic nature of the charging stock, it is anticipated that the finished gasoline will have anti-detonating properties meeting the most exacting requirements.

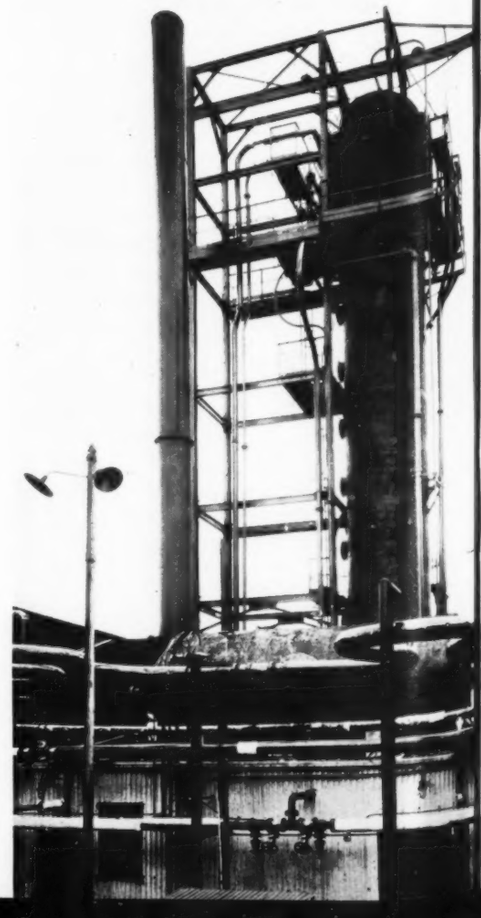
A somewhat similar unit charging 14,000 bbl. of crude per day is under construction for The Pure Oil Company at Smith's Bluff, Texas. Here, in addition to producing finished products of widely varying specifications, there were several crudes which had to be considered as possible charging stocks. In order to secure the maximum flexibility with regard to the character of the crude charge, it was deemed advisable to provide an additional crude coil built in the same setting as the viscosity breaker. As was the case with the unit previously mentioned, the maximum heat recovery was obtained at the expense of the excess heat generated in the cracking operation and the preheated crude passed through the crude coil which is used merely as a balance on the heat recovery system. Additional sections involved viscosity breaking, reforming, cracking, and gasoline stabilization, the whole integrated so as to give the greatest operating economy.

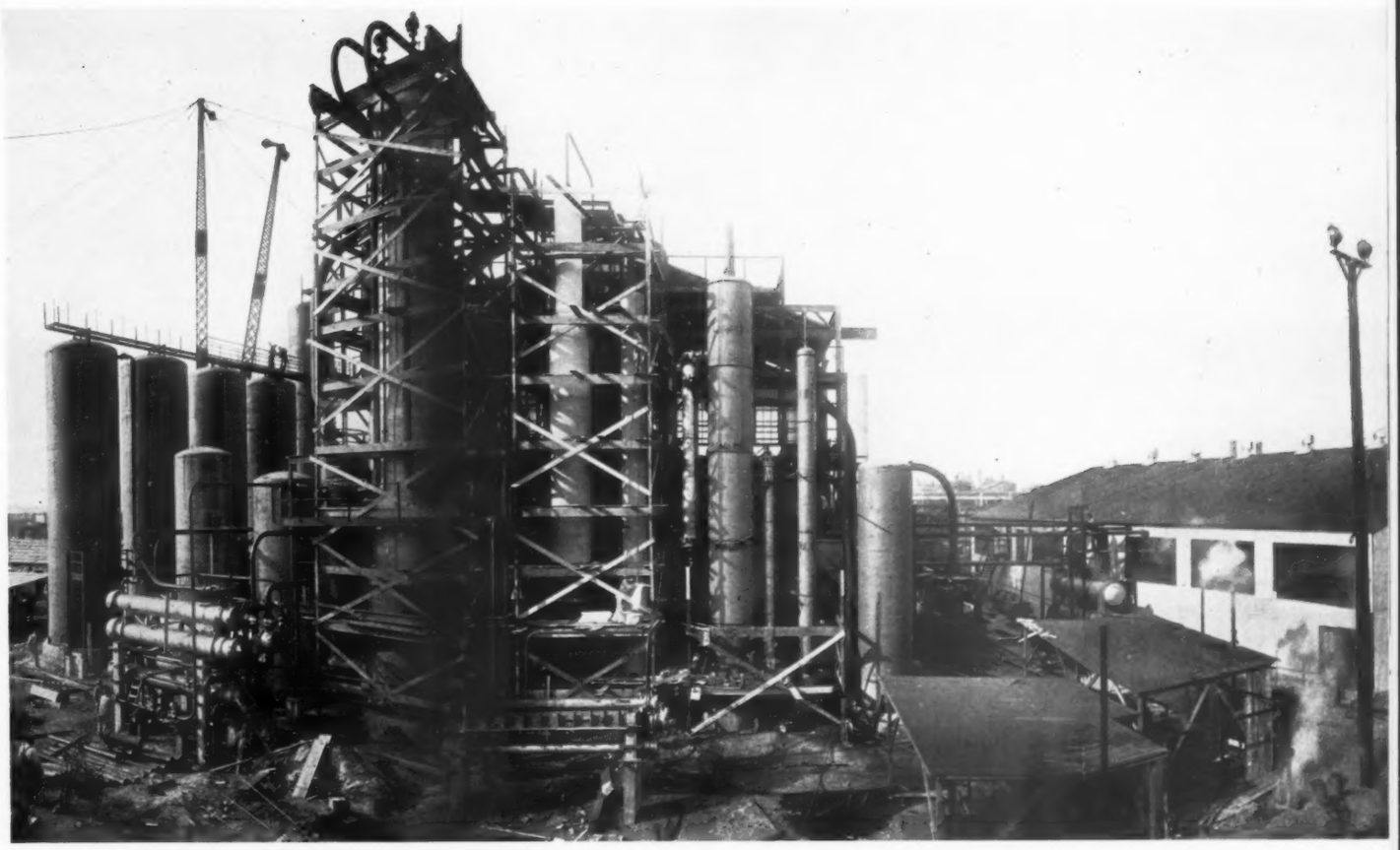
The Lummus Company is at present designing another unit capable of charging 22,000 bbl. of high sulphur crude per day which involves many special features to eliminate or reduce difficulties due to corrosion attendant on operations of this type. Special alloys are used in constructing pumps, towers, piping, etc., the type of alloy being carefully chosen in the light of past experience to give maximum life to the unit as a whole. This cracking unit involves not only crude skimming, reforming, and viscosity breaking, but it also separately cracks virgin and recycle gas oil making it possible to choose optimum conditions of temperature and time so that maximum gasoline yield and octane rating are secured. The virgin gas oil coil operates at 950 deg. F. and the recycle coil at 975 deg. F., the increase in temperature being in proportion to the refractive nature of the stock.

The crude charge to this unit passes through a series of heat exchangers and through a section of one of the gas oil heaters into a fractionating column where the crude is split into straight run gasoline of 275 E.P., crude naphtha, and a small amount of light gas oil. The straight run gasoline which averages about 15 percent on the crude passes into a stabilizer and from thence to storage. The octane rating of this material is high enough to obviate the necessity of reforming. Naphtha from the fractionating column is picked up by means of centrifugal pumps, discharging to a reforming coil operating at a temperature of 1015 deg. F. and a pressure of 750 lbs., the material after reforming being discharged into a high pressure fractionating tower.

The reduced crude from the crude tower is fed into a low pressure fractionating tower operating at about 15 lbs. gauge pressure. In this tower further heat is picked up from the viscosity breaker and

Shell Petroleum Corporation's vacuum pipe still at Wood River, Ill.





Socony-Vacuum's benzol acetone dewaxing plant at Paulsboro, N. J., taken on October 5th, 1936.

the crude material separated into gas oil and topped crude. Reduced crude and cycle stock from the center of the column is charged to the viscosity breaker which operates at a temperature of 875 deg. F. and at a pressure of 275 lbs. This heater also discharges into a low pressure evaporator and bubble tower at a point below the entrance of the virgin reduced crude and is fractionated into fuel oil, recycle stock and gas oil. Gas oil from the viscosity broken material, together with gas oil stripped from the virgin reduced crude, are combined and fed to the virgin gas oil heater, operating at a temperature of 950 deg. F. and 500 lbs. pressure. Fuel oil bottoms from the low pressure bubble tower are steam stripped in a tower stripper to Bunker C specifications. The virgin gas oil cracking coil discharges into a high pressure bubble tower, together with the reformed material, and is separated into gasoline, recycle stock, and fuel oil, the fuel oil being combined with bottoms of the low pressure bubble tower before steam stripping as previously mentioned.

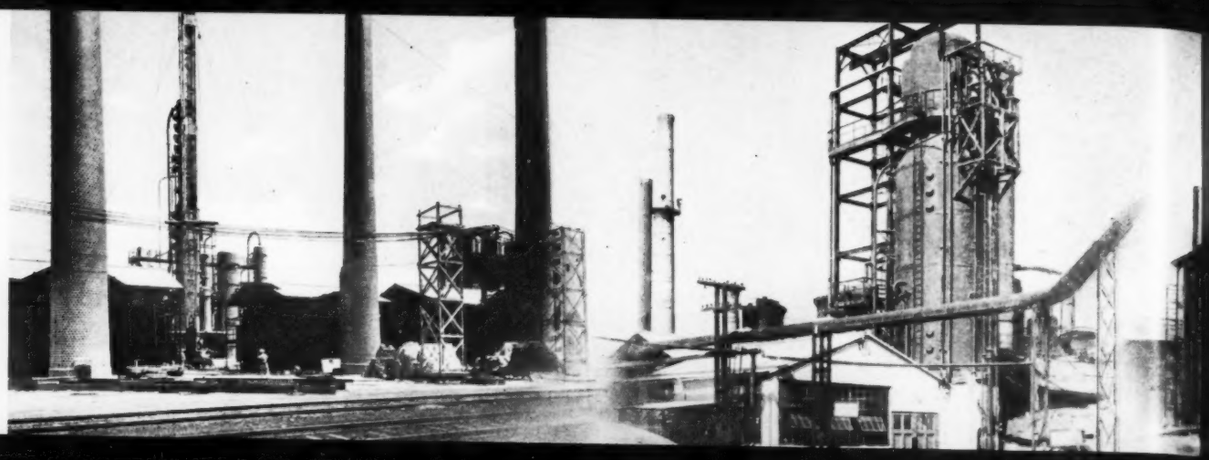
Recycle stock from the high pressure tower is fed to the recycle cracking coil which operates at a temperature of 975 deg. F. and 500 lbs. pressure, and discharges back to the high pressure evaporator and bubble tower. Gasoline from the high pressure bubble tower, after stabilizing, is pumped to the treating plant.

The Lummus Company also modernizes existing units for the purpose of improving charging capacity, yields and quality of finished product. In a recent installation of this type for the White Star Refinery at Trenton, Mich., an existing vapor phase cracking unit was increased in capacity from 4,000 to 6,400 bbl. per day and yield of gasoline increased from 50 to 63 percent. Modernization of this unit involved complete revamping of the existing furnace, numerous changes to towers, heat exchange system, etc. The interesting point in this connection is that the capacity of the heater was doubled with the employment of less heating surface than was originally used. This was accomplished as a result of the inherent design of the Lummus flow which was incorporated.

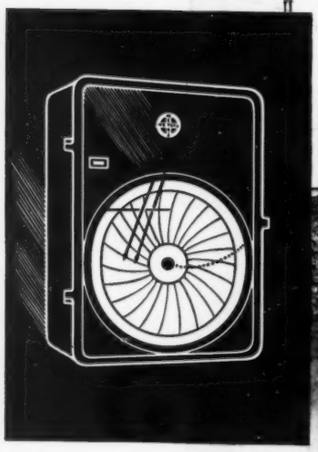
The new flow has the crude enter the plant, pass through heat exchangers, then flash into the middle of the second fractionating tower, bottoms of which are sent through the black oil coil for viscosity breaking.

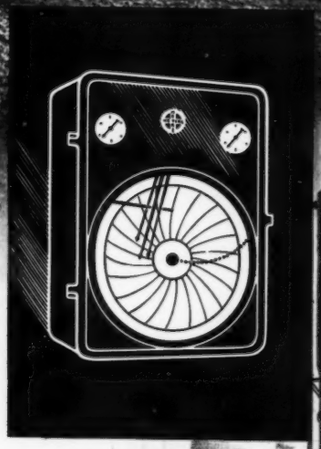
From the third tower a clean gas oil stock is withdrawn as bottoms, then heated in a separate coil to an outlet temperature of 960 deg. F. under 600 lbs. pressure. This stream and the one from the viscosity breaking operation are blended and sent through a soaking section in the convection section of the furnace. In this installation, the Lummus heaters obviate the use of heavy soaking or reaction chambers which permits a closer control of heating operations to within required optimum temperatures.

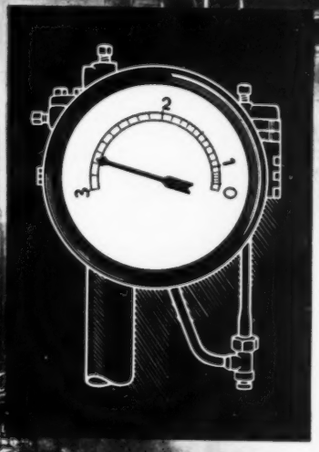
The Lummus type oil heaters installed in these units contain separately controlled heating and soaking sections making it possible to secure proper balance between heating and soaking curves. Design of the furnace is such that heat input at all points in the radiant surface is

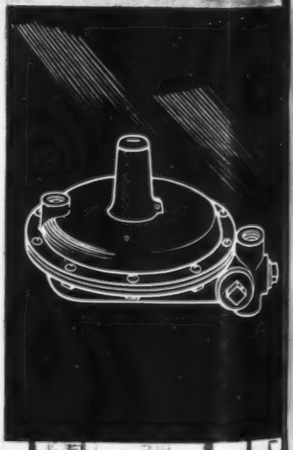


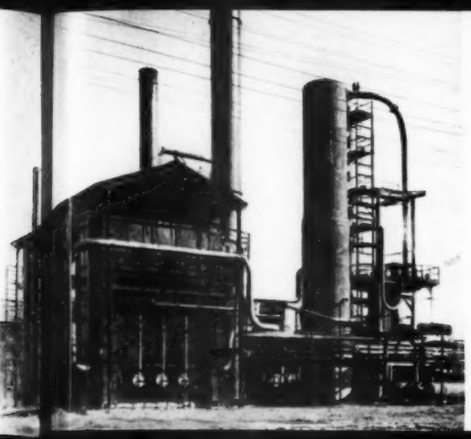
CONTRIBUTING *Accuracy* TO



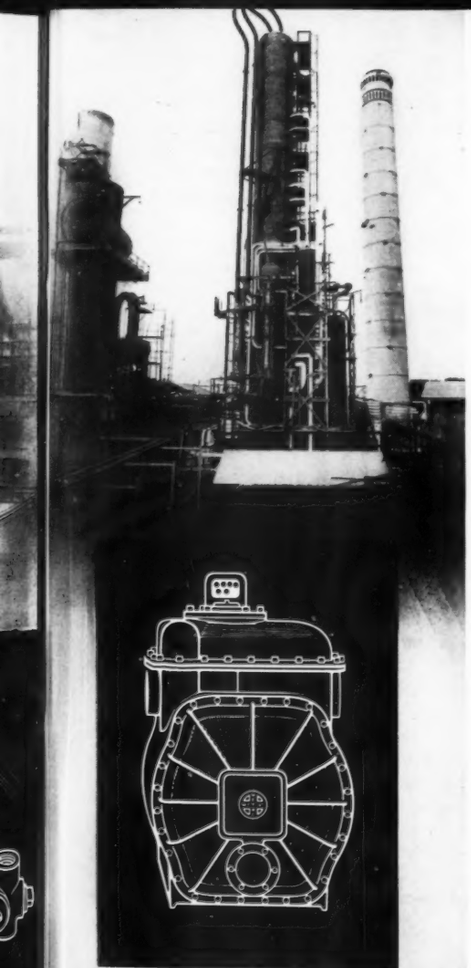








O PLANT EFFICIENCY . . .



MAINTAINED ACCURACY is today a primary consideration in plant operations of the petroleum industry. Visit the important refineries . . . and you will find American Meter world-recognized instruments contributing accurate measurement and positive control of air, gas, steam, oil, liquids.

In Lummus new construction, for example, American Meter Flowmeters are being specified for their dependable, long-sustained accuracy.

Other American Meter safeguards of plant efficiency include gas meters, instruments for rate-volume and liquid level control, gas and air pressure regulators. . . . Applications discussed in new engineering bulletins available on these instruments:

ROUND CASE INDICATING FLOWMETERS utilize the approved orifice method of measurement. The very essential accuracy of orifice plate and differential pressure indicator is built in to stay.

RECORDING AND INTEGRATING FLOWMETERS give progressive, totalized chart readings of the accurately measured flow rates of gas, air or liquids.

RATE-VOLUME CONTROLLERS automatically and accurately maintain the flow of gas or liquid at a predetermined rate. They also are adapted for use as Liquid Level Recorders and Controllers.

REGULATORS of gas and air pressure, have patented exclusive features insuring positive lockup and accurate pressure control.

IRONCASE METERS—standard for accuracy in the measurement of gas at high or low pressures from zero to full capacity — meet an extensive range of requirements. The solid, one-piece body casting prevents internal leaks.

AMERICAN METER CO
MEASUREMENT ENGINEERS
CENTENNIAL
1836-1936

AMERICAN METER COMPANY
INCORPORATED
METRIC METAL WORKS *ERIE, PENNSYLVANIA*

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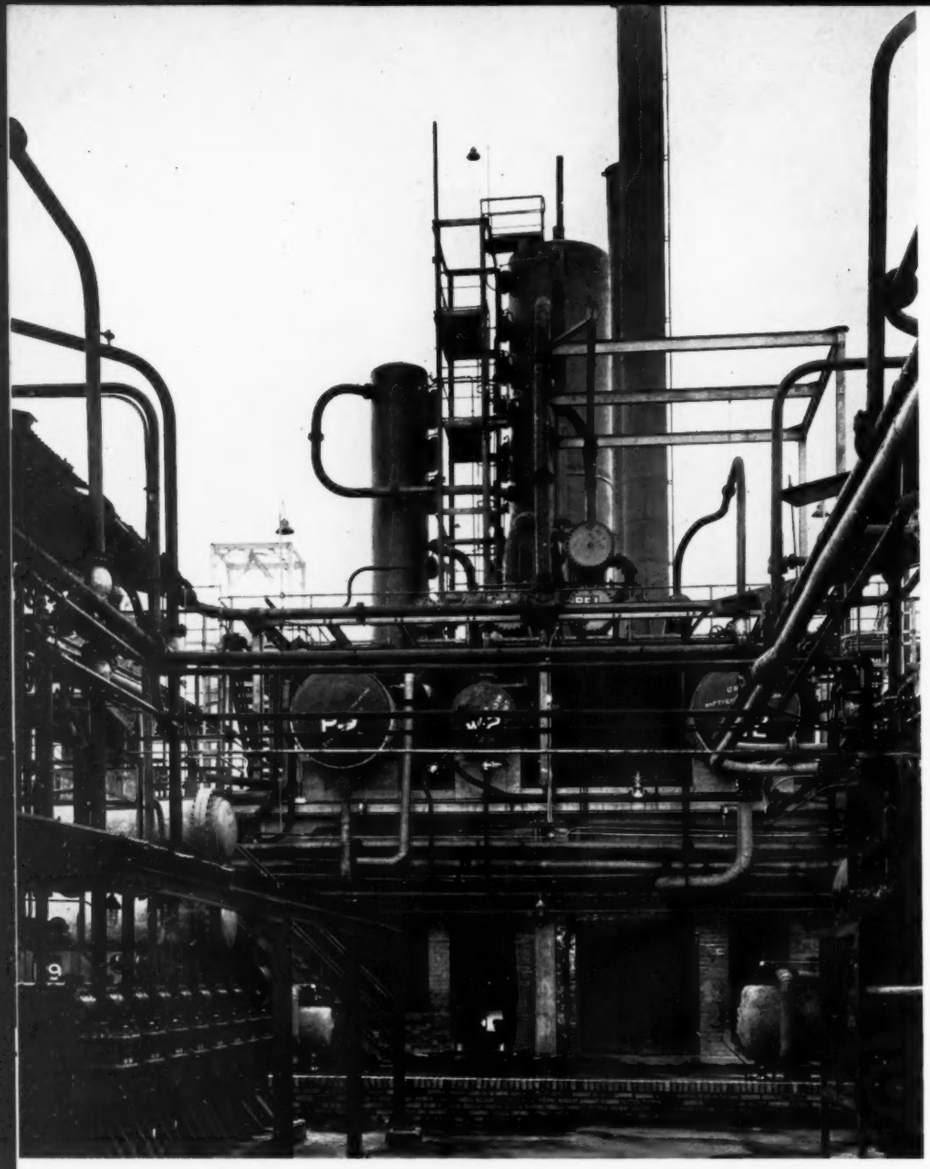


substantially the same, permitting the unit to operate at higher temperatures without undue high heat input at any particular point, and in consequence the hot spots which lead to the formation of coke in the tubes are eliminated. The heater operates with a practical minimum excess of air. All burners are mounted in wind boxes for rigid control of air admitted for combustion. The method of evacuating combustion products from the firing chamber permits operation with low percentages of excess air and eliminates localized overheating encountered with conventional designs of heaters wherein gas temperatures require reduction by dilution with excess air to relieve hot spots. Lummus heaters normally operate with 25 to 35 per cent excess air in exit gases. Stack losses are thereby reduced to a minimum.

View of Duosol plant built by Lummus for Herbert Green in England, taken from the center of the extractor area.

Construction of the setting which is steel encased throughout, including arch and hearth, and the air-tight design of return header housings and doors, eliminates, insofar as is structurally and practically possible, all infiltering air. An additional feature of the heater is an improved convection section wherein high gas velocities are employed with resultant improvement in heat transfer in this section. The increased draft loss that results from construction of the gas passage in the convection section is more than counter-balanced by the absence of any counter stack effect.

Products from Pennsylvania crude have always been used as a criteria for judging the quality of lubricants due to the physical characteristics inherent in this crude. Pennsylvania lubricants are extremely resistant to oxidation, show a very low change in viscosity with temperature, provided they were properly processed to a low solidifying point. The Conradson carbon test on Pennsylvania lubricants was quite high, but as the relationship between this test and the actual engine carbon produced was a highly controversial matter, this was not considered important. Unfortunately, the supply of this crude is limited and the total available production of lubricants from this source was far below that required for automotive, aeroplane and industrial lubrication.

The desire to simulate Pennsylvania quality crude from mixed base or naphthenic crude has resulted in an enormous amount of research which has led to the development of various solvent extraction and dewaxing processes. The operation of many commercial plants has proven that solvent extraction is capable of improving the viscosity temperature slope and oxidation characteristics of lubricating fractions from any crude to a point where they are equal to or better than those secured from Pennsylvania products. Solvent dewaxing has so far developed that the solid materials present in most crude lubricating fractions can be entirely removed and a complete line of motor lubricants with a pour test as low as −25 deg. F. can be produced.

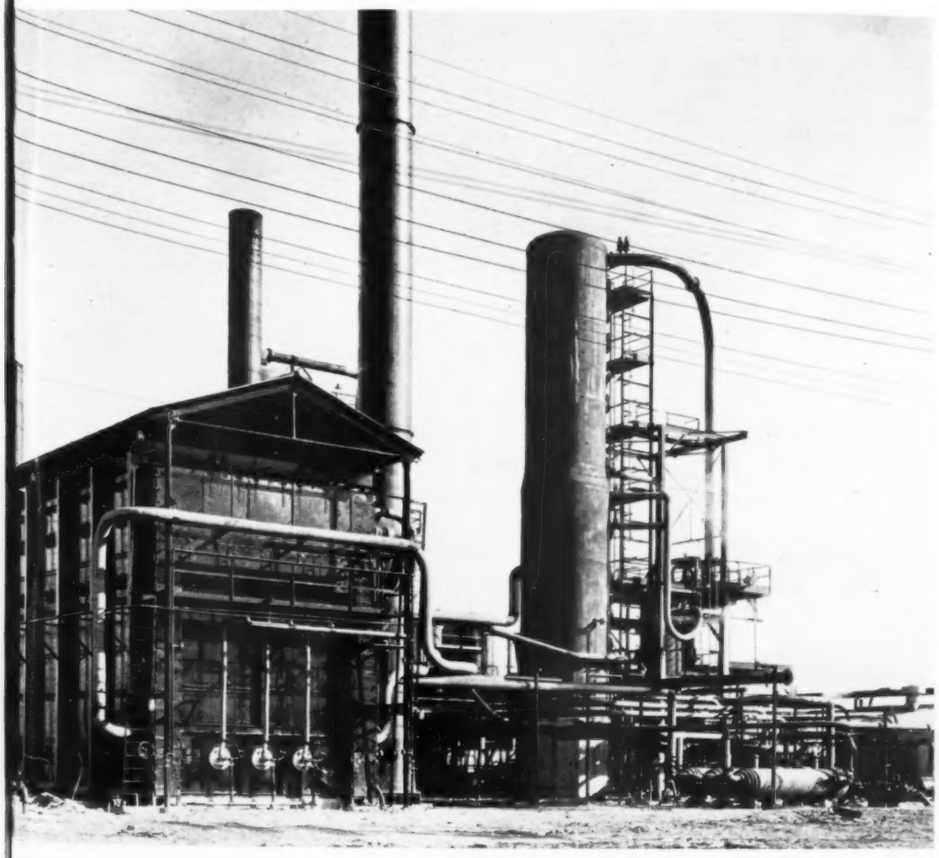
The enormous amount of interest in this subject is reflected in the large number of commercial installations which are either now in operation or under construction. The tabulations shown on page 506 support this statement. It is probably true that no subject has been so intensively studied and so rapidly developed in the history of the petroleum industry as lubricating oil manufacture.

It has long been recognized that there are two important points on the viscosity temperature curve of any lubricating oil, that is, the viscosity at which the engine is required to start under severe climatic conditions and the temperature at which the engine operates. If the temperature viscosity slope of the lubricant is extremely sharp, considerable engine wear is often encountered in starting, particularly at low temperatures, and provided that this is remedied by decreasing the viscosity of the oil, there is insufficient body to secure proper lubrication at the operating temperature.

Recently there have been developed several processes capable of selectively extracting constituents present in lubricating oil to the extent that materials

having very flat viscosity slope can be segregated from those whose slope is not satisfactory. This has made possible the production of high grade lubricants from any crude oil regardless of its source, although the yield of such premium finished products is obviously dependent upon the source of the raw material.

The Lummus Company has been one of the leaders in the design and construction of such solvent plants. In October, 1935, there was completed at the Port Arthur, Texas, plant of the Gulf Oil Corporation, a furfural solvent extraction unit which is the largest solvent refining unit in the world. This plant embodies the steps of both extraction and solvent recovery, together with the necessary drying of the solvent. This unit handles 5,000 bbl. of Coastal crude distillates per day, although it may operate on a wide variety of charging stocks to produce finished products meeting any required specifications. Unusual features were provided in this plant which are responsible for exceptionally low fuel costs. The recovery and drying of the used solvent is accomplished by very simple methods of distillation which do not involve any complicated operating features. The flow through this unit is carried out by pumping the oil to the bottom of the extractor tower while the furfural is delivered to the top and the extraction process is carried out counter-currently with the use of raschig ring packing to furnish large contact surface. The raffinate layer is taken overhead into a surge tank from which it is processed through the recovery unit while the extract layer is withdrawn from the bottom of this extractor surge tank for further processing through the recovery unit. This plant was producing specification products 24 hours after it was placed on stream, a tribute to the care with which the unit was designed.



Above: Recent view of an 8,000 bbl. per day combination cracking unit engineered and erected by the Lummus Company, and below, an atmospheric topping unit of the Shell Petroleum Corporation at Houston, Texas.

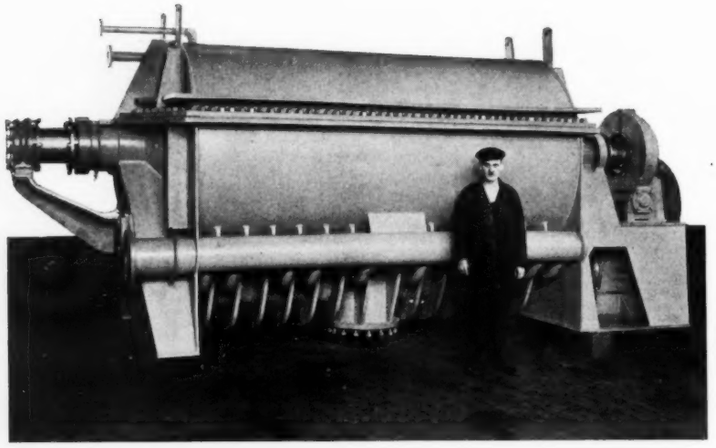
A similar unit is being designed, built, and will be initially operated by the Lummus Company and is located at the Beaumont, Texas, refinery of the Magnolia Petroleum Company. The engineering involved in the design of both these units results in very efficient heat consumption and high solvent recovery, key factors in the economy of any solvent refining process.

The table (p. 506) shows the lubricating oil solvent extraction units and indicates the success of furfural in this field.

The Duosol process of solvent extraction is quite well known to the industry through numerous articles appearing in various trade journals. In this process the crude material, usually a residual, is extracted with a mixture of propane and cresylic acid with about 40 per cent phenol usually being added to the cresylic acid to improve the miscibility temperature.

The Lummus Company designed and constructed four of these units, one of the first having been constructed for the Socony-Vacuum Oil Co., Inc., at their Paulsboro, New Jersey, plant. This plant

Filter Equipment Furnished for

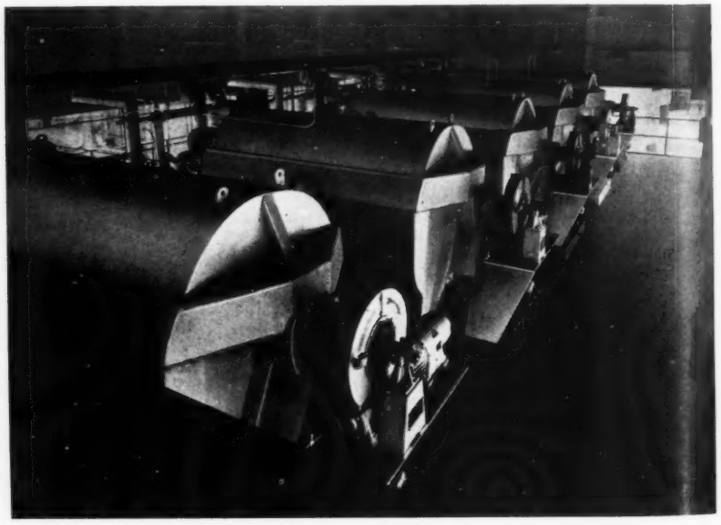


800 sq. ft. Vallez Pressure Filter installed in the Socony-Vacuum Oil Company Refinery at Naples, Italy by The Lummus Company.

The Vallez Pressure Filter

The original solvent oil dewaxing filter, first installed at the Indian Refining Company plant at Lawrenceville, Indiana in 1928. A rotating leaf pressure filter for totally closed cyclic operation that has been an unqualified success in each installation, comprising some 32 filters to date.

Unexcelled manufacturing facilities are available in our shops for fabricating large filter equipment of this type. The manufacturing and operating experience acquired from successful installations are part and parcel of each and every Goslin-Birmingham filter.



Five 800 sq. ft. Vallez Filters installed in the Gulf Refining Company's Benzol-Methyl-Ethyl-Ketone dewaxing plant at Port Arthur, Texas.

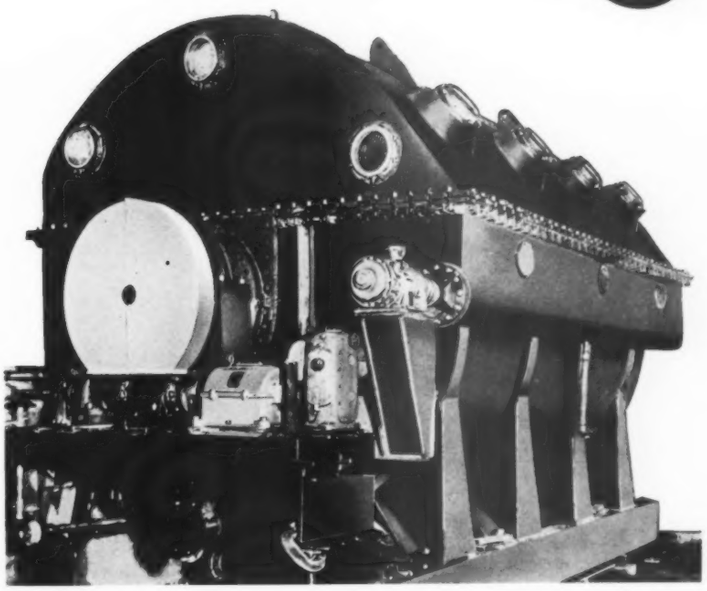
GOSLIN-BIRMINGHAM

NEW YORK, 56 Pine St. CHICAGO, 20 N. Wacker Drive

17,000 Bbl. Daily Dewaxing Capacity GB

The Goslin-Wright Vacuum Filter

The continuous vacuum drum type of totally enclosed filter for solvent oil dewaxing—incorporating all recent improvements and refinements and fabricated in large sized units for large production capacities. Twenty filters of this type have been fabricated in Birmingham for solvent oil dewaxing plants.



500 sq. ft. Goslin-Wright vacuum driven filter for Socony-Vacuum Oil Company plant at Paulsboro, N. J., installed by The Lummus Company.

10 ft. diameter by 16 ft. face drums. Shop dressing station.

Goslin-Birmingham filter equipment for the oil refining industry includes solvent oil dewaxing, contacting of gasoline, kerosene and lubricating oils, doctor solutions and other products.

Our nearest office will be happy to consult with you for further data.

MANUFACTURING COMPANY, INCORPORATED • BIRMINGHAM ALABAMA, U. S. A. GB

SAN FRANCISCO, 244 9th St. NEW ORLEANS, Balter Building

Left; The largest solvent refining unit in the world—built by the Lummus Company, and below, one of the Lummus heaters that comprise a uniquely efficient section of recent installations.

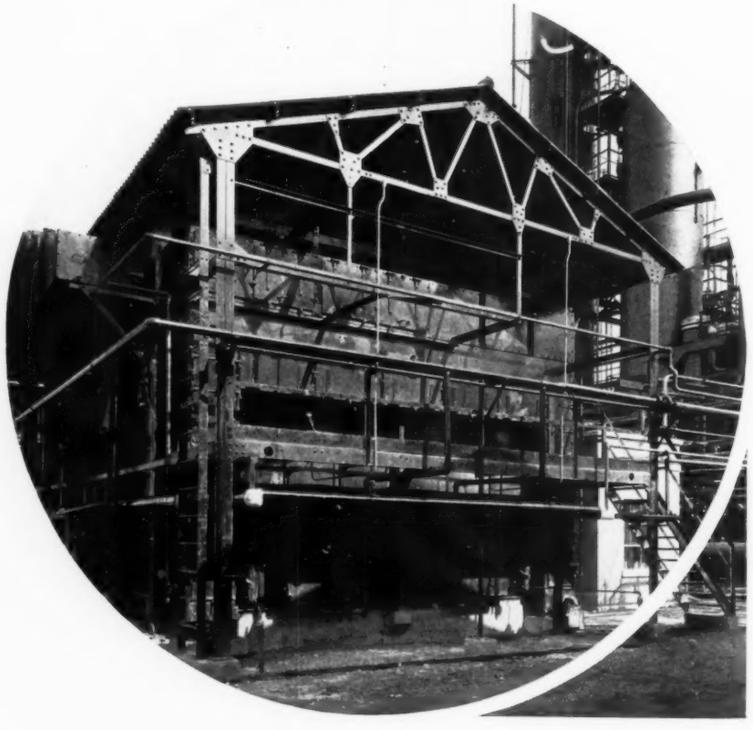
charges 4,200 bbl. per day of heavy residual from Oklahoma City crude. The other unit, embodying the features of this process, was built for the Gulf Oil Corporation at their Girard Point, Pennsylvania, plant and charges 2,700 bbl. per day of a somewhat similar charging stock. A third unit was designed and constructed by the Lummus Company for the Magnolia Petroleum Company at Beaumont, Texas, which charges 2,800 bbl. per day of heavy Oklahoma City stock and the fourth unit was for Herbert Green and Co. in England with a charge capacity of about 1,400 bbl. per day.

The presence of solid paraffin wax in a finished lubricating oil is obviously objectionable, for the presence of such material necessarily means that the lubricant is solid at low temperatures and it is impossible for the motor to secure satisfactory lubrication while starting under these conditions.

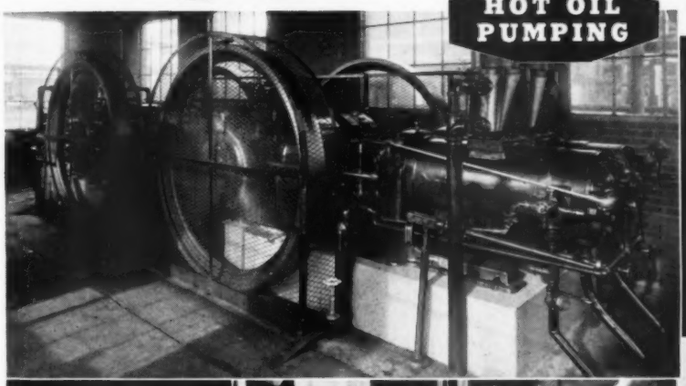
The Benzol Acetone Dewaxing Process has gained wide favor as a method for removing these objectionable solid compounds as attested by tabulation following on page 506.

Lubricating stocks can be dewaxed by this method to finished products having pour tests of within a few degrees of the dewaxing temperature, and what is more important, they are entirely free from cloud. Either distillate or residual stocks of widely varying characteristics can be satisfactorily dewaxed by this method.

The industry's general acceptance of this method as the universal means of dewaxing a wide variety of charging stocks is reflected in the construction program which the Lummus organization is completing in October of this year.



COOPER-BESSEMER is in GEAR with all REFINERY and GASOLINE PLANT POWER REQUIREMENTS



1 HOT OIL PUMPING

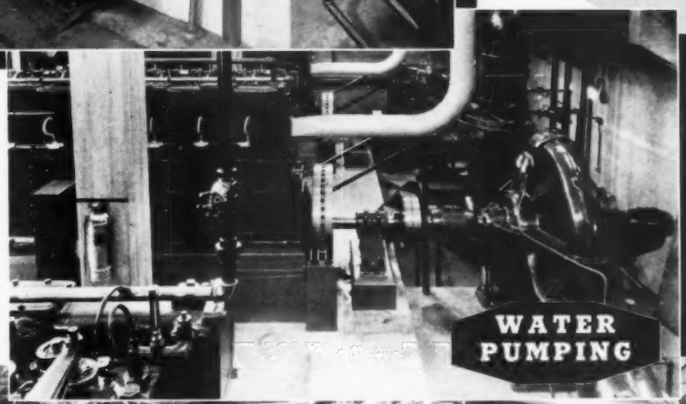
1 Two Type-G-DQ 150-H.P. two-cycle twin-cylinder gas engines driving hot oil pumps in a Toledo refinery.

2 Three Type-JT 535-H.P. four-cycle Diesel engines driving water pumps in a refinery at Cleves, Ohio.

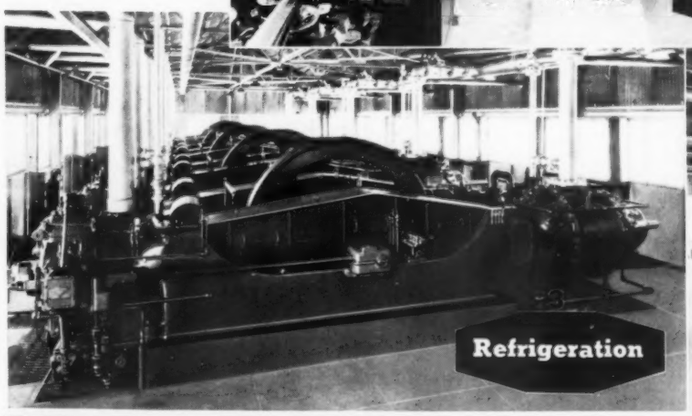
3 Five Type-90 200-H.P. two-cycle twin compressor units used in dewaxing plant of an Oleum, Calif., refinery.

4 Three Type-12 230-H.P. two-cycle twin compressor units, with 3-stage compressors, in gasoline plant near Ahloso, Okla.

SIXTY-FIVE TYPES AND SIZES OF DIESELS, GAS ENGINES AND COMPRESSORS



WATER PUMPING



Refrigeration

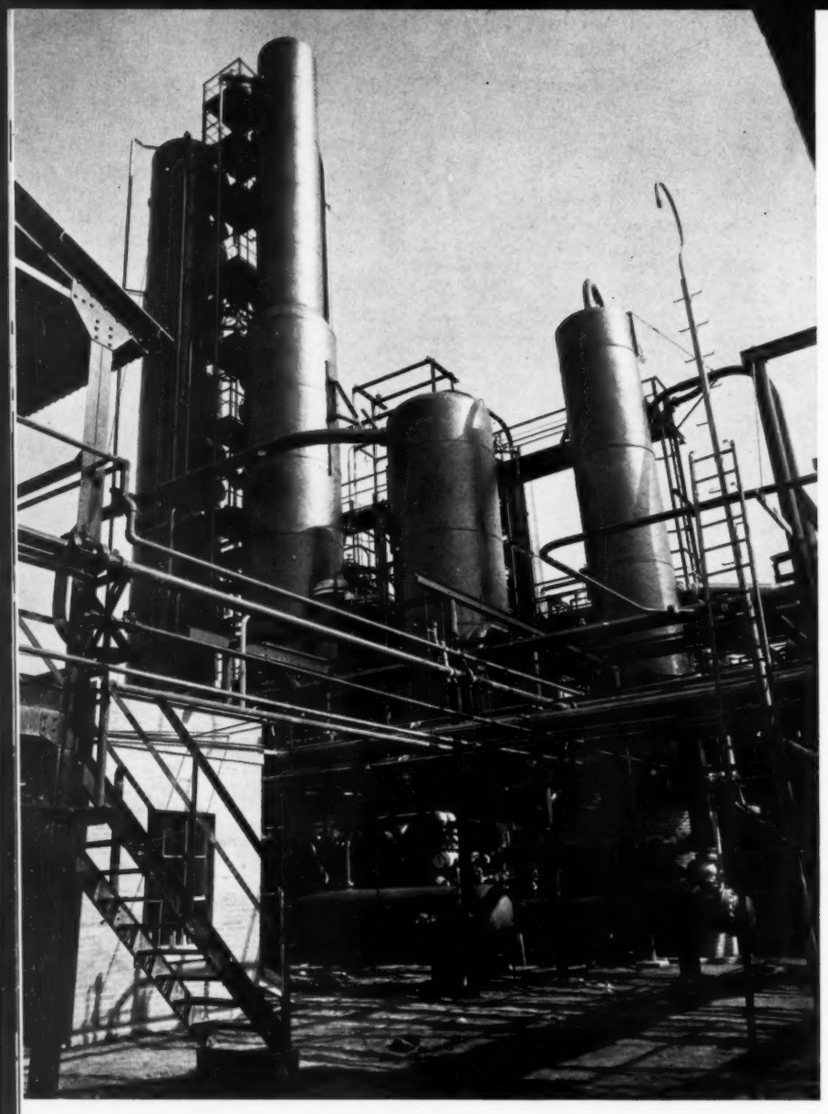
GASOLINE EXTRACTION

THE COOPER-BESSEMER CORPORATION

Mt. Vernon, Ohio — PLANTS — Grove City, Pennsylvania

25 West 43rd St., New York City
Mills Bldg., Washington, D. C.
640 East 61st St., Los Angeles, Calif.
201 East First St., Tulsa, Oklahoma
631 Spring Street, Shreveport, La.
Magnolia Bldg., Dallas, Texas
Esperson Bldg., Houston, Texas

L. W. Rogers, 6 Finsbury Square, London, E. C. 2



General view of the piping on towers between heaters on one of the large combination units now under construction.

One unit designed and erected by Lummus for the Socony Vacuum Oil Company, Inc. at their Paulsboro, New Jersey, refinery will process six different feed stocks with an average output of 3,190 bbl. of zero pour test dewaxed oil per day. By installing additional filter surface, the plant capacity can be increased to 3,690 bbl. per day.

Another plant in construction for the same company at their Olean, New York, refinery, has a charging capacity of 1,428 bbl. per day of several stocks, including petrolatum, wax distillate, and unfiltered steam refined stock. The design is such that the plant capacity may be doubled by the addition of extra filters.

The plant of the Magnolia Petroleum

Lubricating Oil Solvent Extraction Plants

Furfural Process

Company	Location	Charging (BBls Day) Capacity
Gulf Oil Corp.	Port Arthur, Texas	5,000
The Texas Co.	Lawrenceville, Ill.	1,500
The Texas Co.	Port Arthur, Texas	4,000
The Shell Oil Co.	England	1,500
Elwerath	Germany	1,700
Photogen Rafinerie de Petrol	Roumania	300
The Magnolia Petroleum Co.	Beaumont, Texas	3,000
		17,000–28.2%

Phenol Process

Standard Franco-Americaine de Raffinage	France	3,500
Imperial Oil Co., Ltd.	Sarnia, Canada	2,000
The Standard Oil Co. N. J.	Bayonne, N. J.	1,000
The Standard Oil Co. N. J.	Baton Rouge	5,000
The Standard Oil Co. Cal.	California	3,500
		15,000–25.0%

Duo Sol Process

Gulf Oil Corp.	Girard Point	3,700
Magnolia Petroleum Co.	Beaumont, Texas	2,800
The Socony Vacuum Oil Co.	Paulsboro, N. J.	4,200
The Herbert Green Co. Ltd.	England	1,500
Deutsche Vacuum Oel, A. G.	Germany	1,000
Raffineria di Napoli, S. A. I.	Italy	750
Raffineries de la Vacuum Oil Co. S. A. F.	France	750
		14,700–24.5%

Chlorex Process

Standard Oil Co. Indiana	Wood River, Ill.	1,000
Freedom Oil Works	Freedom, Pa.	1,200
Pennzoil Co.	Pennsylvania	1,000
Mid-Continent Petroleum Co.	Tulsa, Okla.	200
Standard Oil Co. Indiana	Wood River, Ill.	1,000
Socony Vacuum Oil Co.	Olean, N. Y.	1,700
Standard Oil Co. Indiana	Casper, Wyo.	600
Bradford Penn. Ref. Co.	Clarendon, Pa.	450
		7,150–11.8%

SO_2 Benzol Process

The Associated Oil Co.	Avon, California	1,500
The Shell Oil Co. of California	California	1,500
The Union Oil Co.	California	1,500
		4,500– 7.5%

Nitrobenzene Process

Atlantic Refining Co.	Philadelphia, Pa.	1,000
The Sinclair Refining Co.	Wellsville	800
		1,800– 3.0%
	Total	60,150–100%

Solvent Dewaxing Plants In Operation Or Under Construction

Benzol Ketone Process

Company	Location	Charging (BBls/Day) Capacity
Indian Refining Co.	Lawrenceville, Ill.	1,850
Atlantic Refining Co.	Philadelphia, Pa.	750
Gulf Oil Corp.	Port Arthur, Tex.	1,600
Herbert Green Co.	East Halton, England	1,000
Deutsche Vacuum Oel A. G.	Bremen, Germany	500
Raffineria di Napoli, S. A. I.	Naples, Italy	500
Socony Vacuum Oil Co.	Paulsboro, N. J.	3,800
Shell Mex and B.P.	Shell Haven, England	1,170
Gewerkschaft Elwerath	Hannover, Germany	1,700
The Texas Co.	Port Arthur, Texas	2,500
S.A. Petrofina	Dunkerque, France	500
Quaker State Refining Co.	Pennsylvania	1,000
Socony Vacuum Oil Co.	Olean, New York	1,500
Magnolia Petroleum Co.	Beaumont, Texas	3,000
		21,370–67.2%

The Propane Process

Standard Oil Co. Indiana	Wood River, Ill.	1,300
Union Oil Co.	Oleum, California	2,000
Shell Petroleum Co.	Wood River, Ill.	2,400
Bradford Penn. Refining Co.	Warren, Pa.	250
Kendall Refining Co.	Bradford, Pa.	1,200
		7,150– 22.4%

The Barisol Process

The Standard Oil Co. La.	Baton Rouge	2,000
The Marland Refining Co.	Ponca City, Oklahoma	500
		2,500– 7.8%

The Trichlorethane Process

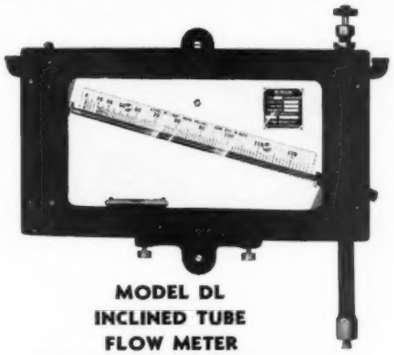
Standard Franco Americaine	Port Jerome, France	850– 2.6%
	Total	31,870–100%

MERIAM

PRECISION INSTRUMENTS

Pure Oil Co., Toledo, Ohio — Pure Oil Co., Nederland, Texas — Shell Oil Co., Houston, Texas

CHOSEN BY LEADERS IN THE INDUSTRY



MODEL DL
INCLINED TUBE
FLOW METER

The body of the instrument is of cast semi-steel. The tube is heavy wall Pyrex glass, gland-packed and replaceable in the field. The drop leg provided, prevents surges in the line from blowing the indicating liquid out of the meter and serves as a return well.

MERIAM instruments are used in the modern plants shown above — engineered and designed by The Lummus Co. of New York City. All three use the Meriam Inclined Tube Flow Meter. This meter is built for ranges of 20" to 50" of water differential using mercury. It can be furnished for the flow measurement of any fluid, air, gas, steam, water, etc., and is designed to operate on line pressure up to 150 lbs.

Also popular is the Meriam Liquid Level Indicator used for measuring heights in tanks of different gravity oils. It is built in ranges for liquid heights equivalent to 10" to 30" of mercury.

Complete information sent upon request.

THE MERIAM CO.
CLEVELAND, OHIO

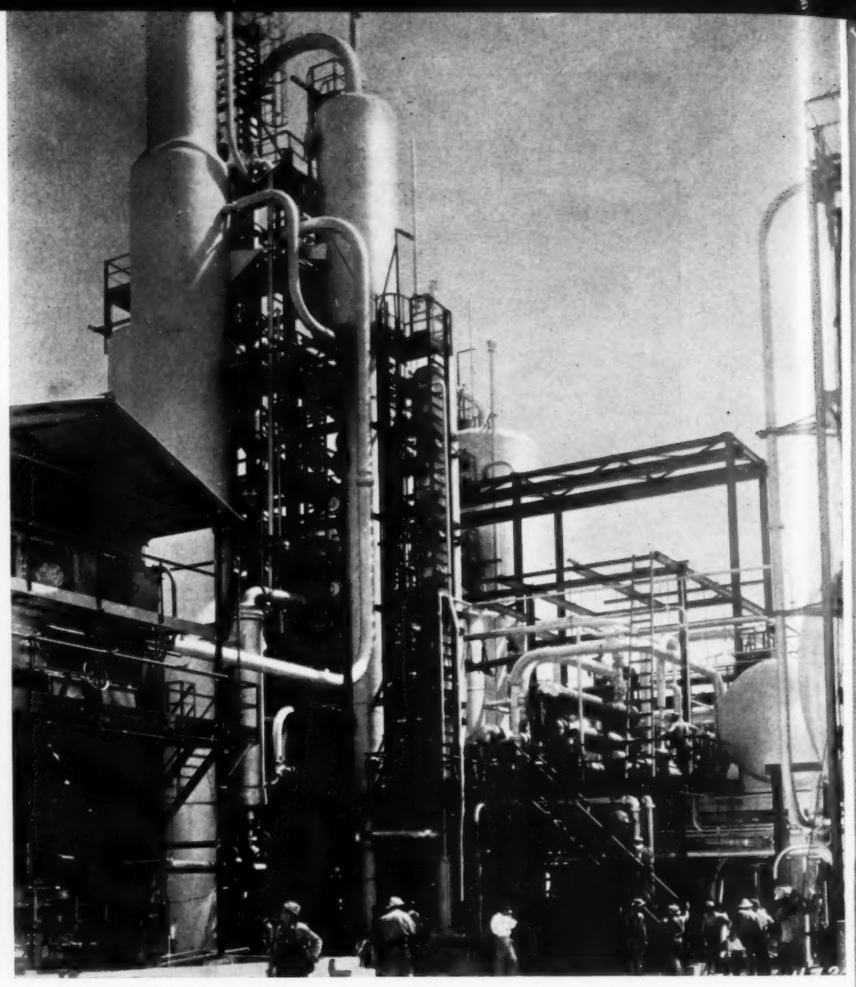
Crawford Eng. Co., New York
S. D. Shook & Co., Pittsburgh
Carl F. Gast, St. Louis
Maleson Co., Philadelphia
Mayer & Oswald, Inc., Chicago
H. R. Bowers, Cleveland

Company at Beaumont, Texas, is expected to be completed in November and has a maximum charging capacity of 3,400 bbl. per day. The fact that this plant will charge solvent refined raffinates from both residual and distillate stocks further attests the flexibility of the process. In all of these units, pour test lower than zero deg. F. may be secured.

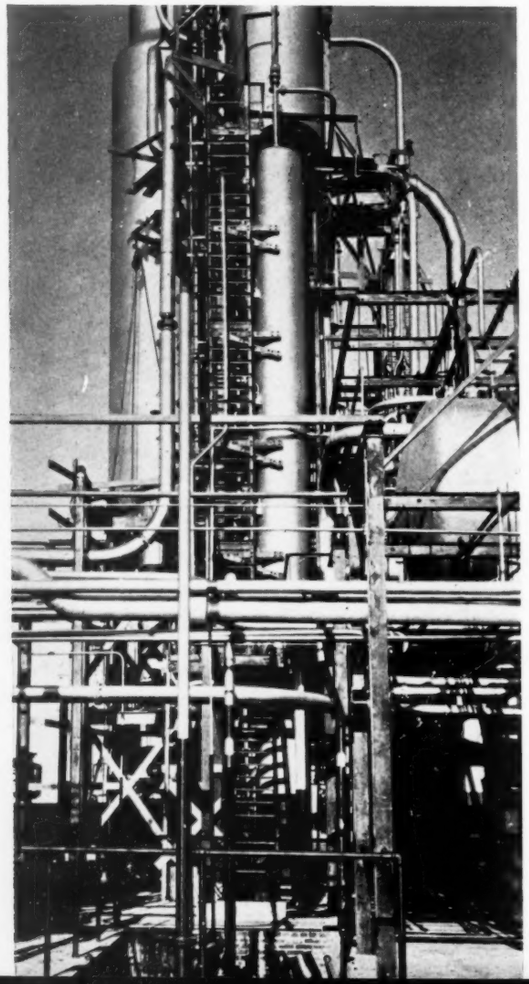
The above plants all employ continuous vacuum filtration and as is the case with practically all continuous processes, this feature offers unique possibilities for securing heat exchange and reducing operating cost.

One of the first adaptations of continuous vacuum filtration to Benzol Acetone Dewaxing was made by the Lummus Company at Bremen, Germany. This plant dewaxes 500 bbl. per day of Duosol raffinate derived from Haenigsen crude and produces a zero pour test finished product.

Other European Benzol Acetone Dewaxing plants are a 500 bbl. per day unit being installed at Napoli, Italy, for Raffineria di Napoli, and a 500 bbl. per day plant under construction for Raffinerie de Petrole du Nord at Dunkerque, France.



Detailed view of the piping in a large solvent refining plant.



View of the heater and towers of a furfural refining unit in the United States built by the Lummus Company.

The former unit will charge Duosol raffinate, and the latter will acid treat Oklahoma City distillates and residues. In either case a zero pour test finished product will be produced.

The Italian plant employs pressure filters of rotary type, whereas the latter uses the previously mentioned continuous vacuum type.

In the majority of these European installations, certain modifications in the usual design had to be made in order that government building specifications could be met. Practically all of the equipment for these units has been purchased in the subject countries and the ability of the Lummus organization to carry out these assignments is a tribute to the excellence of its world wide organization. A thorough knowledge of specifications, materials and conditions prevailing in many countries has been essential for the execution of these contracts.

A complete lubricating oil refinery was built and placed in operation in February of this year for Herbert Green and Co., Ltd. at East Halton, England. This plant is fully described elsewhere in this issue.

At Hannover, Germany, the Lummus Company have erected another complete lubricating oil refinery for Gewerkschaft Deutsche Erdol Raffinerie, which has a charging capacity of 1,600 bbl. per day of 70 percent reduced Nienhagen crude. This plant will produce a complete line of very high grade lubricants for aeroplanes and automobiles, a slightly lower grade product for industrial purposes, and a wide variety of finished asphalts. In order to produce these products from the raw material available, a processing method different from that employed on the Herbert Green plant was deemed advisable. This plant combines Coubrough vacuum distillation, furfural solvent refining, clay contacting, and Benzol Acetone Dewaxing.

The Coubrough Unit reduced crude is fractionated under vacuum into gas oil, light spindle, neutrals, cylinder stock, and asphalts of various grades depending upon

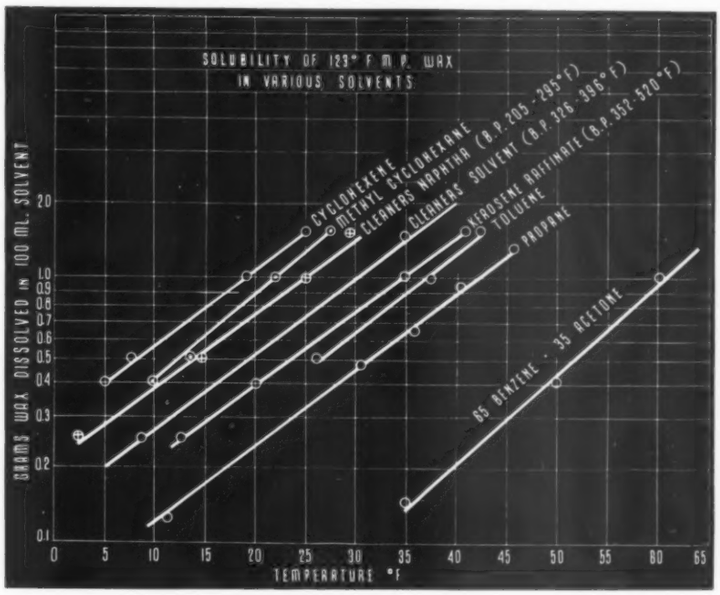
market requirements. Each of the lubricating cuts is subjected to solvent extraction with furfural, contact filtered with activated clay at high temperatures, and dewaxed by the Benzol Acetone method.

Still another Benzol Acetone plant has been designed by the Lummus Company and is being erected by Shell-Mex and B. P. Ltd. at their Shell Haven, England, refinery. This plant is capable of charging 1,510 bbl. per day of furfural refined distillates of widely varying specifications.

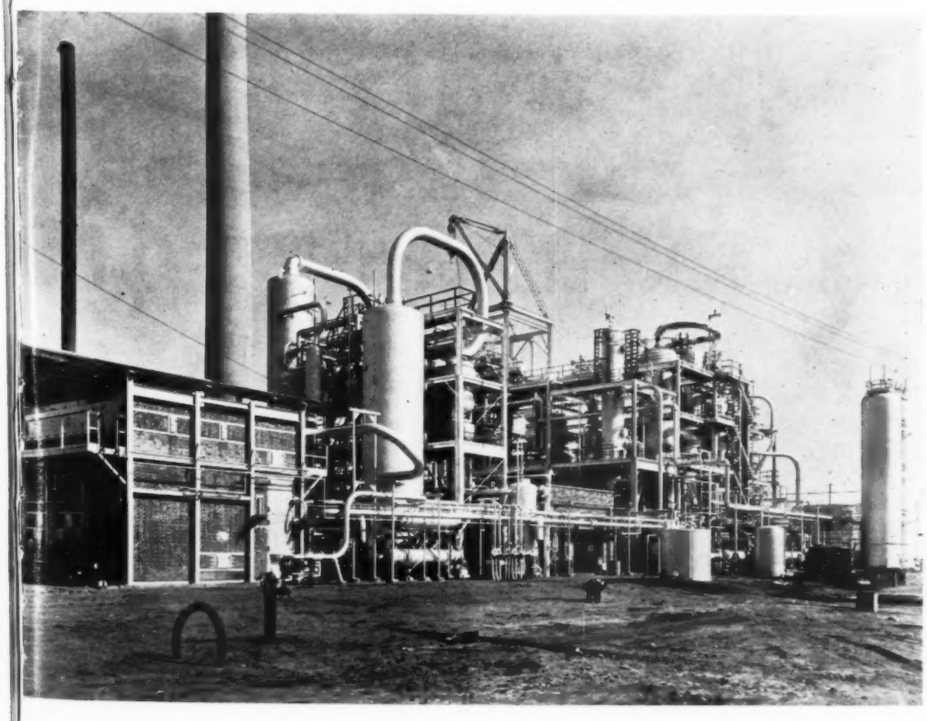
The flow through a dewaxing plant consists of pumping the raw charge oil and the solvent through double pipe heat exchange equipment using the cold pressed oil from the filters as a chilling medium. The mixture is then passed through ammonia double pipe chillers where it is cooled to the filtering temperature of about —10 deg. when producing a zero degree pour oil. The mixture is filtered continuously through drum-type rotating filters, the pressed oil passing through the cloth into a receiving tank while the slack wax which forms a ¼ in. cake on the drum is directed into the slack wax surge tank from the filter drum at the end of its rotation.

The Lummus Company are pioneers in the field of distillation having had forty years' experience in the design of distillation equipment for the chemical and petroleum industries. One of the first fractionating columns installed for petroleum rectification was erected in California in 1922 by the Lummus Company. Since that time Lummus has steadily pioneered in this field and some of their recent installations attest to the exacting specifications made possible by their careful design.

At Campana, Argentina, this organization designed and constructed a 6,500 bbl. per day combination atmospheric and


SOLUBILITY OF 123° F M P WAX
IN VARIOUS SOLVENTS
GRAMS WAX DISSOLVED IN 100 ML SOLVENT
TEMPERATURE °F
CYCLOHEXENE
METHYL CYCLOHEXANE
CLEANERS NAPHTHA (B.P. 205 - 295° F)
CLEANERS SOLVENT (B.P. 326 - 396° F)
KEROSENE RAFFINATE (B.P. 352 - 520° F)
TOLUENE
PROPANE
65 BENZENE - 35 ACETONE

Above: illustrating low solubility of wax in benzol acetone solvent, and below, another large solvent unit designed and constructed by the Lummus Company.



vacuum pipe still unit to process San Pedro and low test Peruvian crude for the Standard Oil Company of New Jersey. This contract was let on the basis that Lummus was to place the unit in operation not later than six months after the award of the contract under a bonus and penalty arrangement. In order that this could be accomplished, most of the material was designed and prefabricated in the United States prior to shipment to the Argentine. The dispatch with which this was accomplished may be realized by the fact that two towers, one 8½ ft. in diameter by 92 ft. long, and the other 12 ft. in diameter by 50 ft. long, were shipped completely assembled seven weeks after the award of the contract. In Argentina, special railroad cars had to be built by the construction force to transport these towers forty miles to the site of the unit.

All process and auxiliary piping was completely fabricated and tested in shops in the United States, then sent to the field

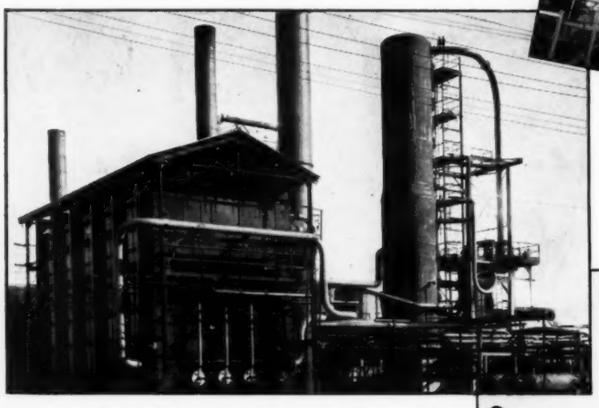
Three outstanding new LUMMUS installations have operating efficiency stepped up with

EAGLE INSULATION

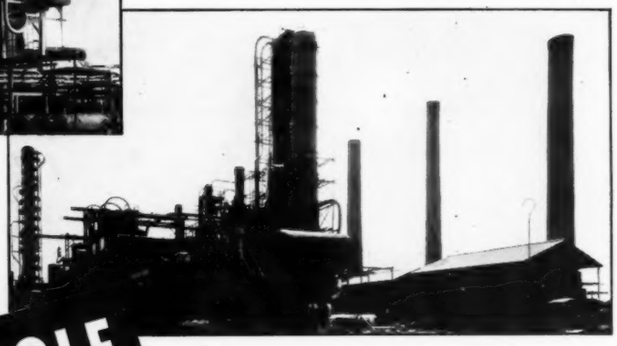
Complete jobs planned and installed by Eagle Contract Department • Eagle Insulating Materials have proved their high efficiency in scores of refinery units throughout the oil fields. Easily installed and durable, Eagle Insulation goes on cutting operating costs year after year.

Call our Contracting Division the next time you have a tough insulation problem to solve. Our experienced engineers will be glad to figure with you in planning an effective, low-cost installation.

Pure Oil Company plant at Netherland, Texas, where Eagle Blankets, Eagle "66" and Insulseal protect towers and exchanges.



Houston plant of the Shell Petroleum Company. Piping insulated with Eagle Insulating Materials. Towers and exchanges are covered with Eagle "66" and Eagle Insulseal.



New Pure Oil unit at Toledo, Ohio. Complete insulating job for Lummus equipment was planned and installed by the Eagle Contract Division.

Eagle-Picher offers a complete line of Insulating Materials for Refineries . . . including

Eagle Super "66" Plastic Insulation. Easy-to-apply one-piece insulation. Extremely efficient for temperatures up to 1800° F.

Eagle Blanket Insulation. Insulating wool felted and secured. For towers, boilers, breeching, furnaces.

Eagle Insulseal (waterproofing cement). Durable coating protects all heat insulation against exposure.

Eagle Asbestos Lumber. Structurally strong. Fireproof. Resists heat and weather.

Eagle "77" Pipe Covering. Insulating wool felted and secured. Flexible and easily applied. Particularly adapted for hot lines where a cement finish is desired.

Eagle "BX" Insulating Brick. An extremely strong, light weight insulating brick. Easy to cut. Resists spalling. For temperatures up to 2400° F.

Eagle "Verox" Insulating Brick. A light weight, efficient insulating brick for backing up refractory walls or roofs. For temperatures up to 2000° F.

EAGLE INSULATION SERVICE FOR OIL REFINERIES

THE EAGLE-PICHER LEAD COMPANY
Dept. WP-10, Cincinnati, Ohio

Please send me, free, your illustrated booklet, "Effective Heat Insulation."

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Solvents for Lube Oil Refining
Classification of Solvent Characteristics and Performance

Solvent	Furfural	Phenol	Chlorex	Duosol	Nitro-Benzene	Edelaneau SO_2-Benzol
Plants Operating	5	5	7	5	2	3
Plants Building	2	–	–	2	–	–
Total bbl. per day charge	17,000	15,000	6,150	15,000	1,800	4,500
Selectivity	Good	Good	Good	Good	Good	Good
Separability	Good	Fair	Requires Stage Mixing	Fair	Mixing and Settling	Good
Stability	Good	Good	Decomp.	Good	Fair	Good
Boiling Point	323° F.	358° F.	353° F.	Pro.-48 Acid 358–396	412° F.	+14° F. and 176° F.
Extraction Temperature	150°–250° F.	100°–180° F.	60°–80° F.	60°–90° F.	50° F.	90°–115° F.
Toxic and Corrosive Properties	None	Toxic Slight Corrosive	Toxic Corrosive	Same as Phenol	Toxic Corrosive	Toxic and Corrosive

properly marked for assembly. It took approximately two months to design and fabricate all materials for delivery along side the steamer, one month for ocean transportation, one month for clearing customs, two weeks to get the equipment from seaport inland forty miles to the refinery, and one and a half months for erection. The unit was completed ahead of schedule, met all guarantees and was accepted shortly after construction was completed.

Another vacuum unit built by the Lummus Company was constructed for the Barber Asphalt Company at Maurer, New Jersey, charging 6,000 bbl. per day of 60 percent reduced Venezuelan crude. This unit produces a wide variety of asphalts meeting practically all commercial specifications.

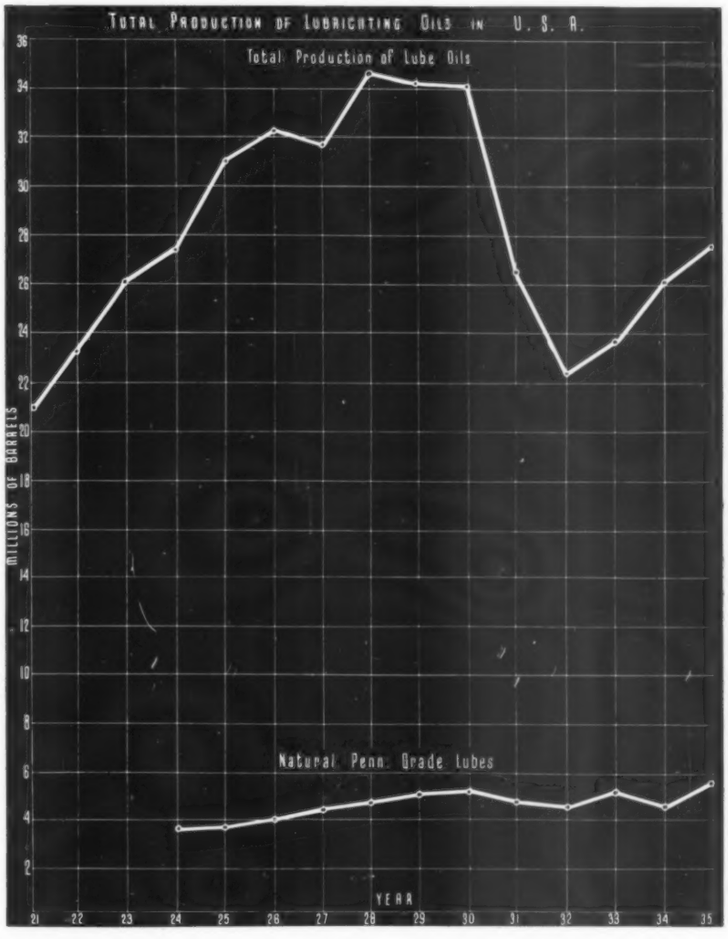
An interesting feature of this unit is the overhead condensers which are built integral with the tower. This feature reduces pressure drop and obviates the necessity for complex supporting structures.

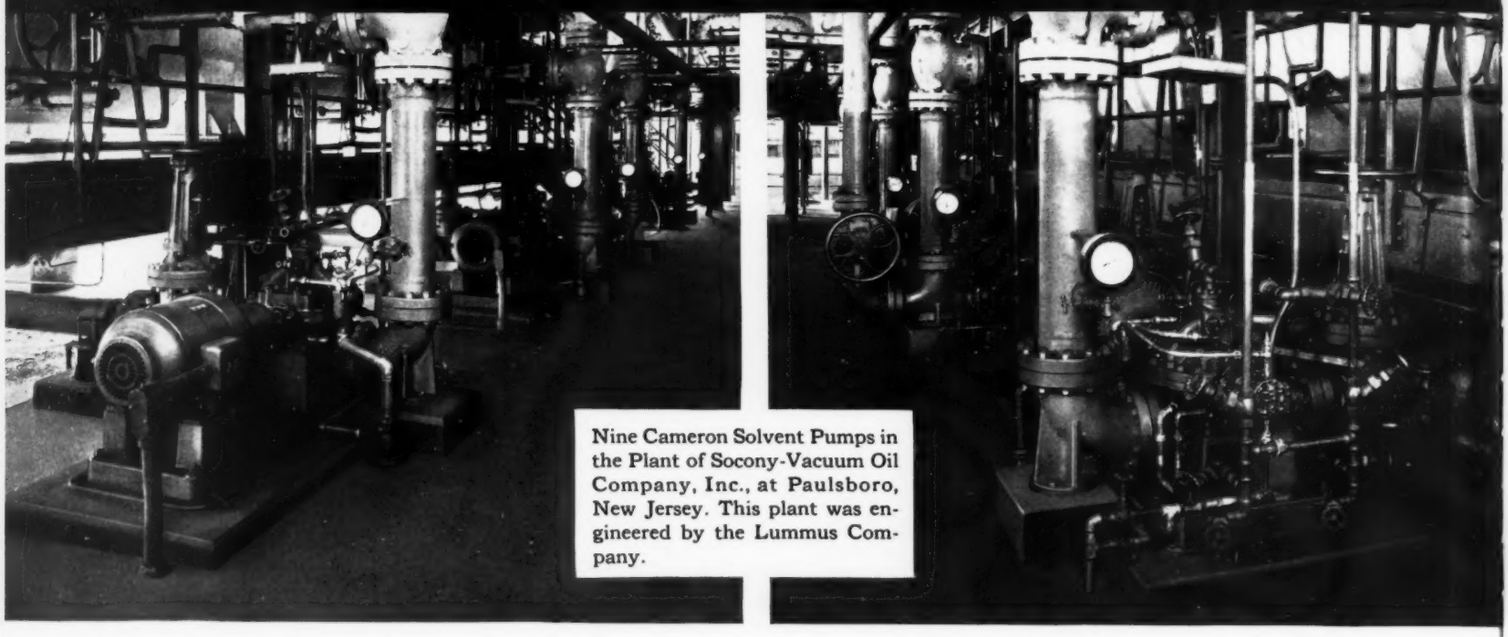
Another interesting feature incorporated in this design and the use of which is optional depending upon the quality of the finished asphalt desired, is the use of a carrier to aid in distillation. This Coubrough feature consists essentially in diluting the residuum with a light hydrocarbon such as kerosene or gas oil, heating the mixture in a conventional tube still, which discharges into the vacuum column. Use of the carrier reduces partial pressure of heavier fractions, enabling the unit to run to a low percent residuum, in this case asphalt. Viscosity of the mix going to the tube still is also reduced which obviates the possibility of getting high skin temperatures in the tubes, and consequently cracking the oil to the detriment of the quality of the asphalt.

A vacuum pipe still designed and engineered by the Lummus organization for Shell Petroleum Corporation at Wood River, Illinois, has a novel vacuum fractionating unit, employing shower decks instead of the conventional bubble cap type. The unit processes 6,300 bbl. per day of 25 deg. A.P.I. reduced Mid-Continent crude. As high as 40 percent of the charge can be taken overhead with a tower diameter of eight feet. The bottoms have a close cup flash point of 400 deg. F. with not over five percent boiling at 400 deg. F. under 10 mm. vacuum. The shower decks have the advantage that tower diameter can be smaller because of the higher allowable velocity and pressure drop through the tower is less than is obtained with bubble cap type. This results in a higher vacuum in the flash zone than would otherwise be attainable. In addition to these technical advantages, internal construction is more economical than the bubble type deck.

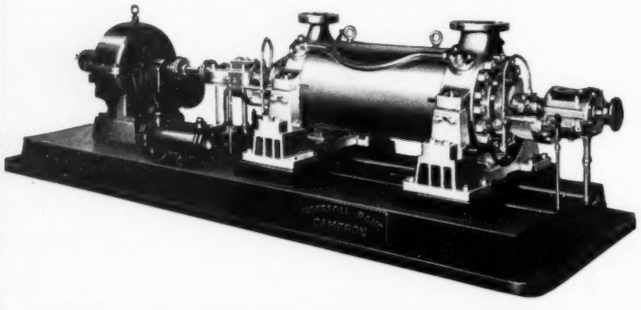
Another unit now being designed and constructed by the Lummus Company for the Gulf Oil Corporation, at Port Arthur, Texas, charges 1,200 bbl. per day of previously solvent dewaxed and chemically refined lubricating oil long residuum, fractionating the products into various grades of neutrals and bright stock. The refiner decided to install Lummus equipment on this particular job due to the

Supply of Pennsylvania grade lubricating oils in relation to total production of lubricating oils in the United States illustrating why so many solvent refining plants are being built.

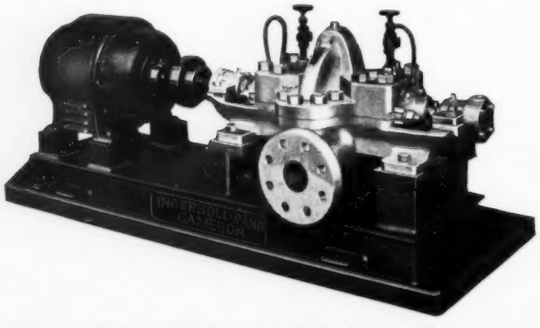




Nine Cameron Solvent Pumps in the Plant of Socony-Vacuum Oil Company, Inc., at Paulsboro, New Jersey. This plant was engineered by the Lummus Company.



AHT pumps are especially designed for cracking coil charging service. A few of their many advantages are: High sustained efficiency over long periods of operation; low attendance and maintenance costs; small foundations and space requirements; non-pulsating flow and ability to operate close to the maximum still pressure. They are built for pressures up to 1600 pounds per square inch.



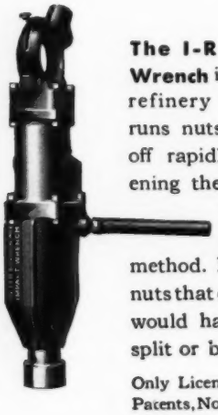
Classes JVL and CJVL are built for handling hot oil, distillates, gasoline, propane, butane and solvents. They are single-stage units with capacities up to 1200 g.p.m. against heads to 600 ft. and for temperatures to 750° F. Such units have a variety of applications in refineries. Thousands of them are in successful operation.

INGERSOLL-RAND has had wide experience in building pumping equipment for oil refineries. The units illustrated on this page have been developed in cooperation with foremost refinery engineers. Their satisfactory performance in numerous installations of all types has proven the correctness of their design.

Ingersoll-Rand engineers are always glad to cooperate and furnish data on any pumping problem.

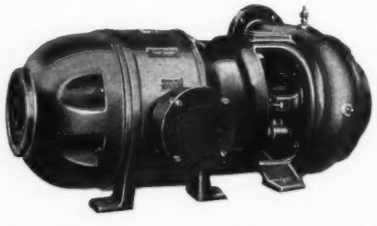
Cameron pumps and Ingersoll-Rand compressors are in use in the following plants engineered by The Lummus Company:

Atmospheric and Vacuum Pipe Stills, Compana, Argentina.
Furfural Refining Unit, Gulf Refining Co., Port Arthur, Texas.
Combination Cracking Unit, White Star Refinery, Trenton, Michigan.
Topping Unit Addition, Shell Petroleum Corp., Houston, Texas.
Benzol Acetone Dewaxing Plant, Socony Vacuum Oil Co., Paulsboro, N. J.
Combination Cracking Unit, Pure Oil Co., Nederland, Texas.
Benzol Acetone Dewaxing Plant, Magnolia Petroleum Corp., Beaumont, Texas.
Furfural Refining Unit, Magnolia Petroleum Corp., Beaumont, Texas.



The I-R Impact Wrench is an ideal refinery tool. It runs nuts on and off rapidly, tightening them better than by any other method. It loosens nuts that ordinarily would have to be split or burned off.

Only Licensee of Pott Patents, Nos. 2,012,916, 2,049,273.



Motorpumps are compact pumping units for general service. Their high efficiency and sturdy construction have been proved in hundreds of refinery installations. They are available for capacities from 5 to 1000 g.p.m. for heads to 500 ft.

delicate operation involved. Cracking had to be entirely eliminated if the proper flash and color specifications of the finished oil were to be obtained, and the Lummus heater proved to be entirely suited for this type of operation.

The Lummus Company has under construction a Coubrough and Vacuum Unit at Tokyo, Japan, which is being built for the Asano Bussan Company, Ltd. The unit consists mainly of a single vacuum tower and a stripper and is designed to take off an overhead cut, five side cuts and asphalt bottoms. The charge to the unit is to be Poso Creek crude having the following characteristics:

Gravity	16.5
Viscosity	79 S.S.U. at 210
Initial Boiling Point	340
10% Point	505
20% Point	593
50% Point	830

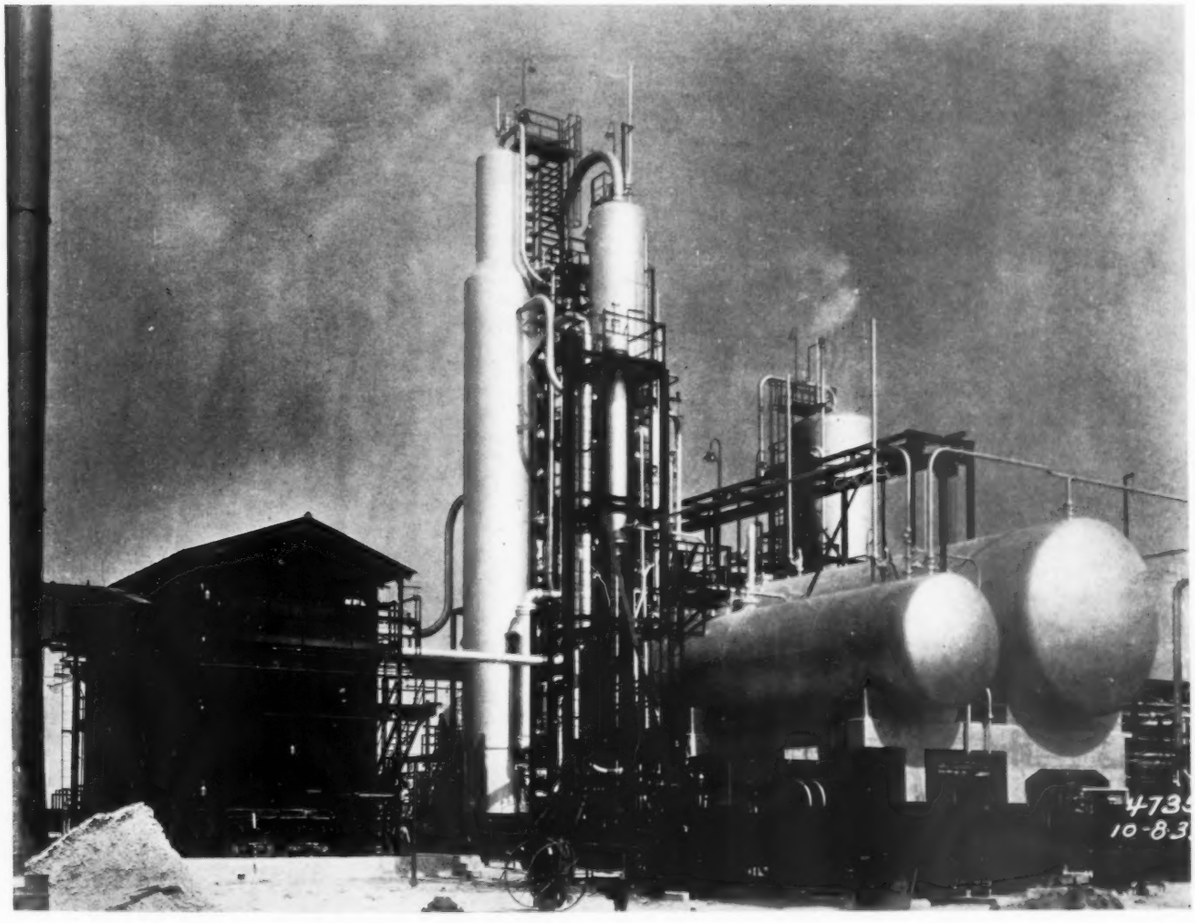
The following products will be produced from this crude oil:

	A.P.I. Grav.	Viscosity
Naphtha Distillate	38	
Gas Oil	29.5	
Transformer Oil	24.5	54 S.S.U. at 100
Light Lube Oil	22	80 S.S.U. at 100
Medium Lube Oil	18	60 S.S.U. at 210
Heavy Lube Oil	15	150 S.S.U. at 210
Asphalt	5.3	25 pen. at 77

The adaptability of the Lummus design to the present trend towards high capacity distillation units is well illustrated by the topping unit installed for the Shell Petroleum Company at Houston, Texas. This installation involved remodeling an existing 10,000 bbl. per day atmospheric topping unit for the purpose of increasing its capacity to 25,000 bbl. per day. This unit incorporates a two coil Lummus type heater.

An interesting unit recently completed for the Pure Oil Company at Nederland, Texas, handles three grades of crudes,—East Texas, VanZandt, and Bosco. This unit required great flexibility in the fractionating equipment to produce a number of very close cuts, such as rubber solvent, V. M. & P. naphtha, Stoddard solvent, in addition to standard grades of kerosene, gas oil, and furnace oil.

The crude coming in after heat exchange passes through the furnace and is flashed into the first tower, bottoms of which are removed and after stripping are delivered to the second tower where the stock is reboiled. In order to reduce coil outlet temperature in flashing off the products desired, it is necessary to resort to a double flash operation. Outlet temperatures of the first flash are kept down in the neighborhood of 500 to 550 deg. F. while the reboiling operation where the products are for cracking is carried around 775 to 800 deg. F. Since the unit was designed to take off a large number of products, including close cut solvents, the above



Furfural refining unit, Gulf Oil Corporation, Port Arthur, Texas, charging 5,000 bbl. of raw lubricating oil per day; plant erected by the Lummus Company.

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flashing and heating arrangement was very important.

Extreme in flexibility of design of fractionating equipment is well illustrated by the naphtha rerun unit recently put into operation for the Gulf Oil Corporation at Port Arthur, Texas. This unit reruns 3,600 bbl. per day of four different acid treated distillates producing an overhead cut and four side streams and bottoms meeting rigid specifications of very narrow boiling point solvents. The design of the columns is such that the initial and final boiling points of some side cuts may be gapped if necessary.

Long a leader in alcohol and chemical distilling apparatus, Lummus has played an important part in the construction of stills for the recovery and purification of petroleum and chemical byproducts. In the past eighteen months Lummus has built a wide variety of special equipment for the concentration and fractionation of the numerous chemicals and solvents which today are byproducts of petroleum refining or are used as refining agents. These include alcohols; solvents and treating agents special petroleum cuts; acids and such chemicals as acetic acid, formaldehyde, carbon tetrachloride, etc.

▼

Practical Research

By Ward J. Bloomer

THE DESIGN of distillation equipment processing petroleum fractions from any crude oil or fractions from crudes from different world sources requires the knowledge of their varying properties such as gravity, boiling points, viscosities, specific heats, latent heats, critical temperatures and pressures, molecular weights, etc. Much of this data is contained in published literature and much more is contained in the private files of refinery and equipment manufacturers' petroleum laboratories. There are also available many empirical relationships of quasi-theoretical foundation which correlate these data with sufficient accuracy for preliminary design purposes.

Unfortunately many of these relationships, though based on the best data available at this time are inadequate as a thorough means of attack on the problems set by the compounds, temperatures and pressures of the refining industry. Too strict a dependence on their usefulness for other than preliminary design may introduce errors incompatible with the engineering requirements of present day equipment.

It will be readily agreed, that supplementing these empirical relationships with actual refinery or pilot plant refinery operation on each specific problem should provide a greater degree of accuracy in design of both distillation or component treating units.

It is for this reason that the Lummus Company maintains at Bayonne, New Jersey, a pilot refinery completely equipped for distillation, acid or clay treating, furfural extraction, acetone-benzol dewaxing and the miscellaneous processes involved in complete refining.

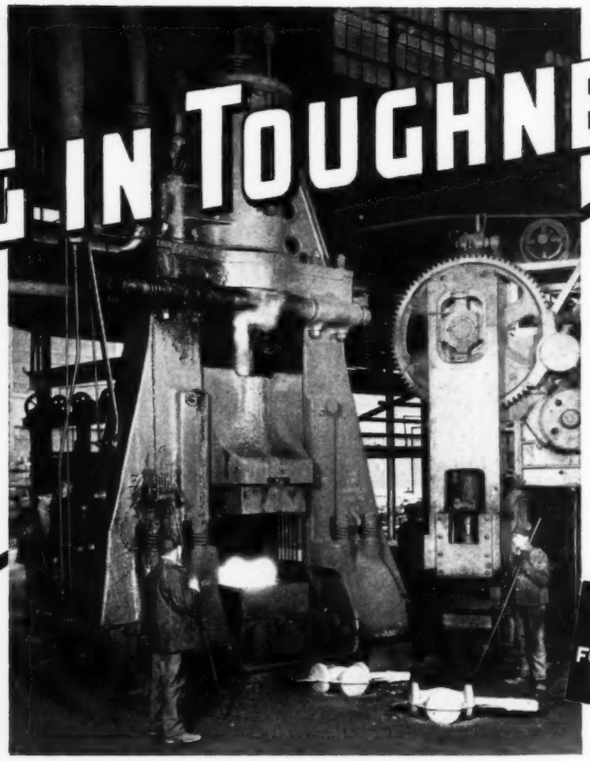
The company is prepared to accept any sample of crude oil or any component thereof from one gallon to one hundred drums for the purpose of complete and prompt technical analysis. Their semi-plant refinery is equipped with seven distillation towers, five in the 16 inch and two in the 9 inch diameter size, designed for continuous operation at normal or reduced pressures, complete with steam stripped side drawoffs and the normal operating accessories. Two gas fired and two oil fired tube stills are designed for exact and easy control of transfer temperatures of stocks fed to this unit. The towers are built with an eye to the complete flexibility required by the process demands of a very wide variety of domestic and foreign crude oils and derivatives. To assist in the frequent changes necessary to maintain this flexibility, a well staffed and equipped machine shop is an important part of the laboratory. The technique employed in the construction of the distillation towers is one that permits a partial or complete rearrangement of deck layout and spacing to suit the varying needs of each new job. It is seen that with heaters and towers capable of processing one hundred barrels of crude per day or twenty five barrels of residual stock per day, samples may be prepared of a size sufficient for any subsequent treating. In this connection it should be noted that the operating conditions encountered in the laboratory refinery have been almost exactly duplicated in the finished refining units constructed by the company. For this reason complete confidence is enjoyed by the company in guaranteeing yields and specifications of products anticipated in the larger refinery built as a result of this work.

For example, a recent research on a German topped crude oil required a complete finished lubricating oil evaluation including gas oil, spindle oil, neutral oil, light and heavy machine oils, light and heavy cylinder stocks, and low penetration in the raw asphalts. These distillate oils were all produced in sufficient quantities for subsequent furfural treating, acetone-benzol dewaxing, and contact filtration to finished products. To check actual aeroplane motor performance, one ton of finished S.A.E. 60 stock at 90 viscosity index, 0 deg. F. pour, and 8 NPA color was furnished the refiner. In the course of the work complete data were obtained for the design of the vacuum reduction, Coubrough distillation, furfural treating, clay contacting, and asphalt production units now in the process of construction.

The facility with which such customer research as the above has been conducted has led in one instance to the reproduction of a portion of the pilot refinery for the development laboratory of one major refiner with the probable construction of at

Instrument board in the large furfural refining unit at Port Arthur, belonging to the Gulf Oil Corp.

BEATING IN TOUGHNESS



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least two more for other refinery research laboratories.

To establish preliminary yields and specifications of solvent treated raffinates and extracts, a pilot furfural countercurrent tower with the necessary solution recovery equipment is available for customer research. A wide variety of oils has been studied in this unit.

A complete and flexible set-up is available for filtrol contacting and filtrol fractionation. Likewise, it is possible to evaluate lubricating oils for wax content in still another unit involving the use of mixtures of acetone and benzol-toluol or methyl ethyl ketone and benzol-toluol.

It will be noted elsewhere that the Lummus Company has designed and built approximately 83 percent of all the solvent refining and dewaxing plants designed or built by contractors in the world and approximately 95 percent of lubricating oil plants built by contractors in Europe.

It might be expected then that the major portion of the research is connected with the production of high quality lubricants from partial or complete combination of Coubrough vacuum distillation, furfural solvent extraction, contact filtration and benzol acetone dewaxing units. These processes produce finished oils of high viscosity index, minimum pourpoints, low carbon forming tendencies and high resistance to oxidation from charging stocks of any initial quality.

As a corollary to work done on lubricating oils in the heavy end of the crude oils, the Lummus pilot plant is equipped for the production of the entire range of saleable asphalts or road oils. As an example, complete design information and asphalt specifications were secured on Venezuellan stocks prior to the construction of the 6,000 bbl. per day refinery for the Barber Asphalt Company at Maurer, New Jersey. Each of the ultimate products was produced in sufficient quantity for detailed study and for future customer sample purposes. Here again an extremely close check on pilot plant and refinery operating temperatures, pressures, yields and specifications was secured.

The same service has been rendered domestic and other refiners producing asphalt from such varying sources as East and West Texas, Russia, India, Iran, Mexico, Trinidad and Germany. It will be seen that the possibilities of developing a new or increased market prior to the actual completion of the refinery unit makes the investment more attractive.

To keep pace with or set the pace for the company's other activities in the industrial and beverage alcohol field as noted elsewhere, considerable research has been conducted in solvent fermentation and solvent recovery. More specifically a recent lengthy program resulted in the successful establishment of practically theoretical yields of butanol, acetone, and ethyl alcohol from molasses on a semi-commercial basis. Fermenters ranging from twenty-five to three thousand gallons in the pilot plant made a jump to the sixty thousand gallon fermenters of the projected distillery not the gamble which is sometimes involved in the transference of the results of bacteriological research from laboratory to plant.

Such seemingly different compounds as chlorinated hydrocarbons, absolute alcohol, malonic esters, castor oil, isopropyl alcohol and acetic acid, to name just a few, have been distilled in the nine and and 16 inch diameter semi-commercial fractionating towers of the laboratory prior to the design and construction of large scale units. Proper regard for the corrosion resistant properties of the materials of construction is necessitated by the rapid increase in the number of chemical substances produced by the extraordinary expansion in the chemical industry proper and more recently in the petroleum chemical derivatives field. The laboratory is available to assist in the solution of the new problems arising in the distillation of these chemical by-products and petroleum derivatives. The laboratory staff is frequently called upon to assist in the initial operation of both the petroleum refining and alcohol or solvent distillation units built by the company. Thus the theory, the laboratory benchwork, the semi-plant operation and finally the experience gained by a knowledge of the practical difficulties encountered in the large refinery or distillery are all correlated for the better understanding of the next problem.

Ward J. Bloomer, in charge of Lummus Laboratories, conducting experiments at Bayonne, N. J.

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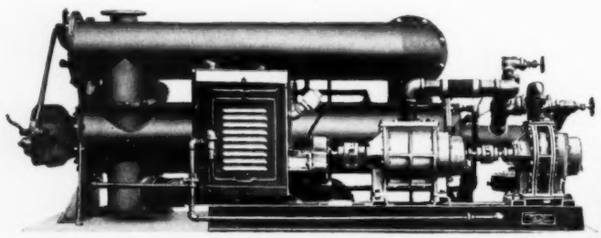
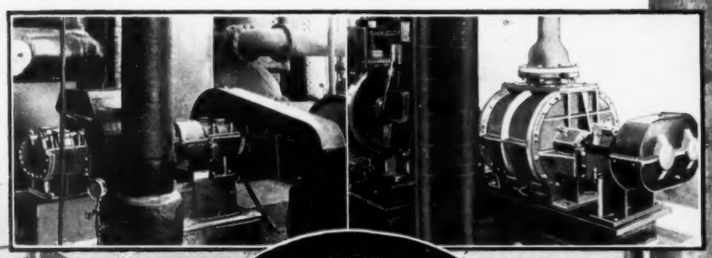
Inert Gas Generators, Cycloidal Rotary Pumps, Rotary Positive Gas Boosters, and Oil Meters, designed or built by Roots-Connersville, are used in solvent dewaxing processes in plants in the United States, and in England, Germany, and Italy. In the fields of distillation, cracking, and other refining processes, numerous other installations have fully established the dependability of Roots-Connersville equipment.



Inert Gas Generator, using either gas or oil, produces gas containing less than 1% oxygen and zero carbon monoxide

Cycloidal Rotary Pump handling cold wax and solvent mixture.

Rotary Positive Gas Pump circulates inert gas at minus 15° F.



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Ancap

By Carlos R. Vegh Garzon

Refinery under construction in Uruguay for Ancap: view from the top of the atmospheric tower.

THE Administración Nacional de Combustibles, Alcohol y Portland, commonly known in Uruguay as ANCAP, is an autonomous institution of the Uruguayan government. The company is the administrator of the state monopolies of alcohol and crude oil refining, also controlling in Uruguay the market of fuels obtained from the distillation of crude. The construction of a large portland cement factory in the near future to supply such quantities of this product as are needed for public works has also been committed to ANCAP.

In order to comply with the terms of the crude refining monopoly and according to its organic law, the ANCAP began in 1935 the construction of its oil refinery which is at present nearly finished. There are no developed oil fields in Uruguay and therefore the ANCAP will process in its refinery Ecuadorian crude oil, the specifications of which are as follows:

Specific Gravity at 60 deg. F. (15.6 deg. C.)	0.8193
Gravity A.P.I.	41.2
Initial boiling point, deg. F.	142 (61 deg. C.)
Distillation at 210 deg. C., %	40
" " 285 deg. C., %	60
End point deg. F.	720 (383 deg. C.)
Sulphur, %	0.05
30% Residue:	
Specific Gravity at 60 deg. F.	0.8922
Gravity deg. A.P.I.	27.1
Sulphur, %	0.09

This crude, when processed at atmospheric pressure distillation, renders the following yields by volume of the charge:

Gasoline	38%
Kerosene	19%
Gas oil	12%
Fuel oil	30%
Gas and losses	1% (maximum)

The refinery of the ANCAP is being erected on a piece of land the greater part of which was covered by the sea a few years ago. This land is located at La Teja, on Montevideo Bay, beside the ANCAP'S storage plant, its area being 22.75 hectares (56 acres) of which the refinery will occupy seven hectares (17.29 acres), the rest being reserved for future extension and the portland cement factory.

On the water side it is surrounded by docks and breakwaters, the water reaching a depth of nine meters (29 ft.).

The refinery is composed of a topping unit; a cracking unit (Dubbs system); a unit for treatment of gasoline in the liquid stage; a unit for alkaline treatment of gasoline; a kerosene treating unit; a central chemical station; a gas holder and gas distribution equipment; a steam generating station; a main pumphouse; a fire defense station and the electrical equipment for the operation of the plant.

The exceptional quality of the Ecuadorian crude to be treated in the refinery makes unnecessary the use of the acid treatment unit for the cracked gasoline, but the company have reserved the right to install it should it have occasion to work with another crude.

A large number of tanks will be necessary for the refinery's operations (nine tanks of 1,500 cu. meters each, ten tanks of 500 cu. meters each and fourteen of 120 cu. meters), as well as interconnecting pipes.

The work of the refinery is controlled by the central administrative office which has a wide and modern laboratory attached, in which control of the finished products will be carried on simultaneously with production.

Sheds for the installation of workshops and warehouses also have been built.

The normal functioning of the refinery pumps will be assured by the use of electric power by all the units, alternative steam-power being provided at points where indispensable.

The materials for the different units mentioned above have been delivered CIF Montevideo together with all the machinery and equipment for the complete installation of the refinery, the thirty-three service and storage tanks, the connecting pipes from the limits of the units to the tanks or to the limits of other units, the electric installation and outside light for the same, the complete drainage system and sanitary works as well as the tank for separating products.

The foundation and erection works of the units and equipments for the refinery have been carried out by the ANCAP with Uruguayan staff and Uruguayan workmen.

The primary distilling (topping) unit, which performs the first distillation to which the petroleum is submitted, will have a capacity to yield, on a normal and continuous running, the amount of 600 cu. meters of crude petroleum per day of 24 hours. It will work independently of

the cracking unit and will consist of the following principal parts:

A Foster Wheeler furnace of the radiation and convection type, with a loading capacity of 600 cu. meters per day of 24 hours with a convection heating surface of 257 sq. meters and a radiation heating surface of 62 sq. meters. The water heater will be placed in the convection bank and will be composed of six steel tubes. The fire chamber will be constructed of refractory bricks for the furnace fire as also the smoke conductors and the chimney. Peabody burners for gas and fuel-oil will be used.

An atmospheric fractionating tower 16 meters high over the platform with 16 bubble trays over the entrance and four below it. It will have five plates and vapor extractors. All full diameter bubble trays and stripping trays will be complete with bubble caps and downcomers. Working pressure will be 0.2 to 0.3 kgs. per sq. cm.

A combined water separator and reflux supply tank, which will work with atmospheric pressure.

Heat exchangers, condensers and coolers will be of the shell and tube floating head type, with removable tube bundle.

A vapor heat exchanger with a total surface of 163 sq. meters.

A vapor condenser with a total surface of 294 sq. meters.

A bottoms heat exchanger with a total surface of 51 sq. meters.

A kerosene cooler with a total surface of 24 sq. meters.

A gas oil cooler with a total surface of 24 sq. meters.

A residuum cooler with a total surface of 31 sq. meters.

An electrically driven centrifugal pump and a steam reciprocating pump for charging.

An electric centrifugal pump and a steam reciprocating pump for reflux.

An electric centrifugal pump and a steam reciprocating pump for residuum.

The charging and reflux pumps will be the cold oil type of cast iron construction and the bottoms pumps will be of the hot oil type of cast steel construction, with extra long water-cooled stuffing boxes.

This unit will have all the control elements necessary.

The yield of the topping unit for the Ecuadorian crude to be treated will be the following: gasoline, 38 percent; kerosene, 19 percent; gas oil, 12 percent; fuel oil, 30 percent; gas and losses (maximum) 1 percent.

The unit is provided with a chimney of reinforced concrete 25 meters high.

The fuel-oil bottoms and part of the gas oil produced by the topping unit will be the charging stock for the fuel and gas oil cracking unit. This will be a full flashing Dubbs unit of the latest type, with absorption column to extract gasoline from the gas produced and combined with the treatment of gasoline in the liquid stage and the gasoline stabilizer unit.

This cracking unit of Dubbs patent will have capacity to produce 30,780 cu. meters per year, of 325 days operation, of gasoline refined in the liquid stage and stabilized. This gasoline production will be obtained with the Ecuadorian crude oil and the charge to the cracking unit will be 60,900 cu. meters of fuel plus 1,300 cu. meters of gas oil per 325 working days.

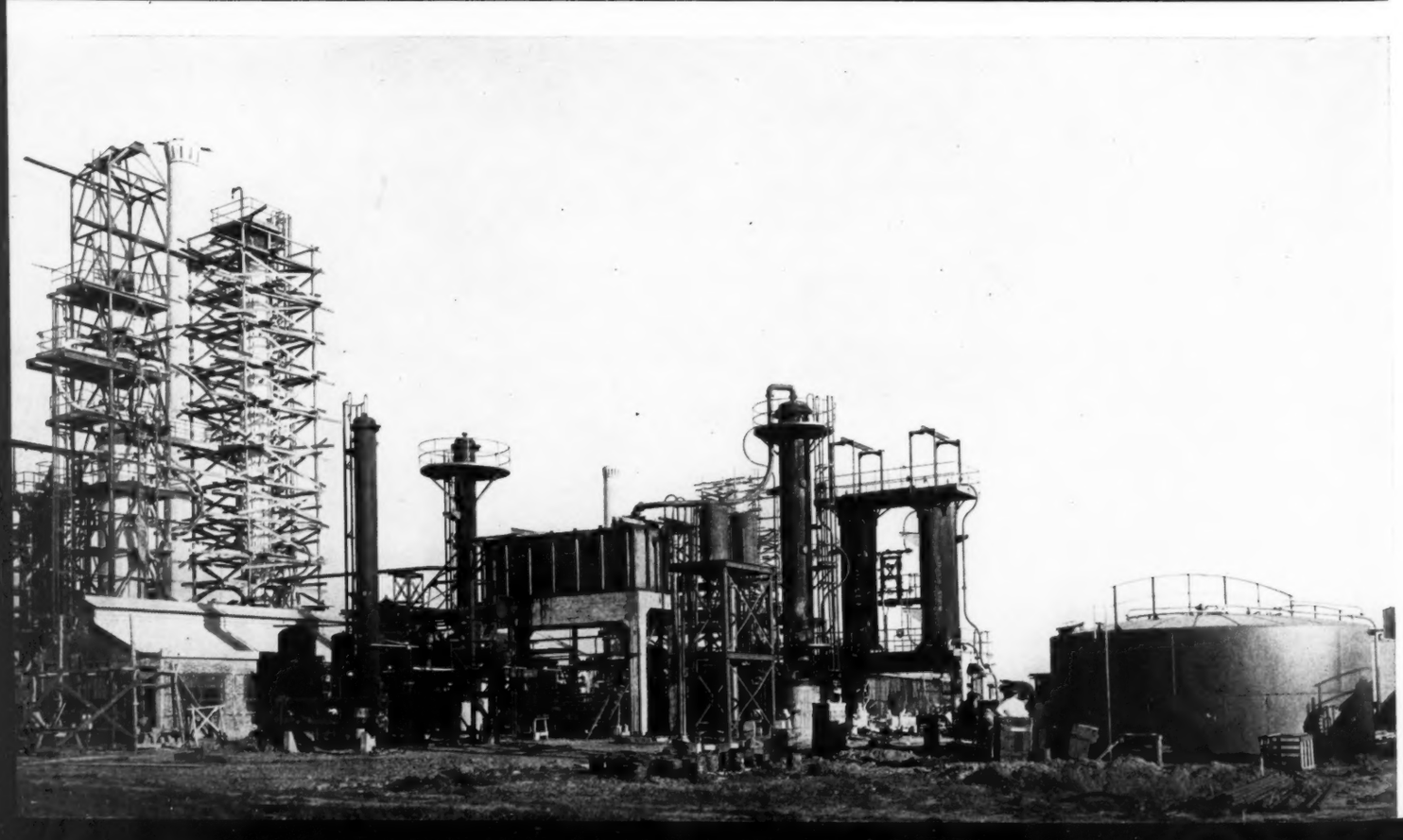
This unit will work independently of the topping unit and will be arranged with necessary connections to permit, if it should ever become advisable, the addition at some future date of a second heater, pumps and necessary piping, thus effecting a selective type of cracking unit.

This unit will be equipped with a Foster-Wheeler radiation type still of approved design with convection section and radiant heat roof and floor tubes. The walls and roof are of Detrick type.

The reaction chamber has walls 90 mm. thick, of steel construction and insulated for a maximum working temperature of 510 deg. C. with 125 mm. monolithic insulation.

The flash chamber has walls 12.5 mm. thick, of electric fusion welded construction and insulated for a maximum working temperature of 450 deg. C. with 100 mm. monolithic insulation.

A high pressure vertical type Leach heat exchanger approximately 1,065 mm. in diameter, is installed on a suitable steel tower, above the flash chamber. The heat exchanger will be insulated for a maximum working temperature of 450 deg. C. with 100 mm. monolithic insulation.



Rear view of Dubbs cracking unit in Uruguay's new refinery.

Warehouse, workshop, boiler house, fire station, and electrical station at the Ancap refinery.

The fractionating column is approximately 1,520 mm. x 19,800 mm., lower half of shell 15.5 mm. plate, and upper half 12.5 mm. plate.

The fractionating column is equipped with 18 cast iron bubble trays with caps and 10 cast iron side to side pans. The column will be insulated for a maximum working temperature, for the lower half of 400 deg. C. and 260 deg. C. for the upper half.

A special building has been erected for the receiver and hot oil pump house with steel roof trusses and pitched roof.

The vapor condenser consists of parallel pipe coils and headers installed in an iron box with suitable baffle plates and inlet and outlet headers.

Three cooler coils consisting of pipe and plug type return bends will be provided, one for recycle, one for bottoms and one for residuum. These coils are installed in a common steel box provided with suitable bulk head nozzles.

The receiver tank is approximately 1 m. x 3.50 mts. x 12.5 mm. walls, of electric fusion welded construction.

The condensate accumulator is of electric fusion welded construction with 100 mm. insulation.

The gas absorption column is of electric fusion welded construction and equipped with approximately 16 cast iron bubble trays and caps.

The unit is equipped with the parts necessary for its working and with the temperature, pressure and flow controls, regulators and recorders of the liquid level, gas controllers, meters, gaugers. It is also equipped with an electric pyrometer of Leeds and Northrup type, including a registrator and indicator equipment.

It has a 40 meter concrete chimney.

The stabilizing unit for cracking gasoline is composed of a debutanizing column with bubble trays, bubble caps and downcomers, and will operate in combination with the cracking unit.

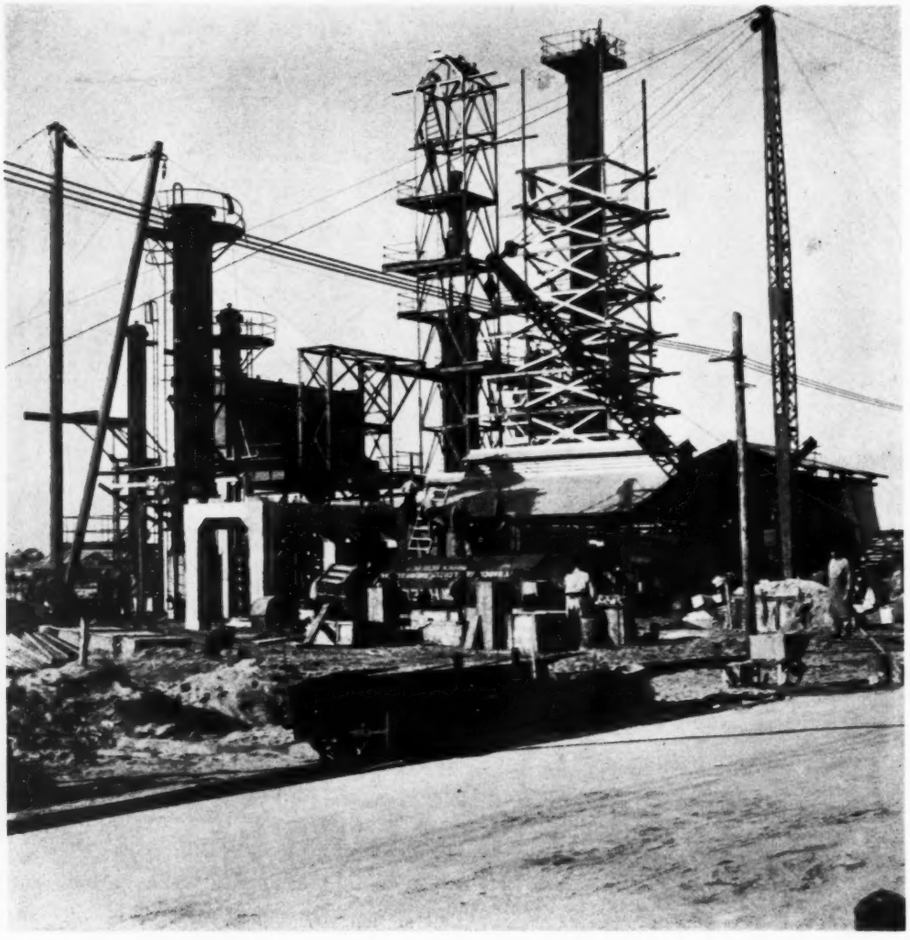
It is equipped with a steam heater, with re-evaporator, with reflux supply tank, with heat interchanger, with condenser and cooler and control instruments.

The unit for treating cracked gasoline in liquid stage is composed of two towers or deposits of a capacity to allow for the treating of the amount of gasoline produced by the cracking unit.

The stabilized gasoline which is collected in the bottom part of the re-evaporator with which this unit is equipped, is taken by a pump and forced through the towers full of clay, which work at a pressure of 18 kgs. per sq. cm. The temperature to be maintained in the towers will oscillate between 210 to 260 or 280 deg. C.

The thickness of the walls of the towers is sufficient to maintain the gasoline in a liquid stage at these temperatures.

The equipment for the alkaline treatment of gasoline will have a capacity for treating under normal and continuous operation 300 cu. meters of gasoline measured at 15 deg. C. per day of 24 hours, this charging product being submitted to the following chemical treatments: (1) Treatment with doctor solution; (2) Treatment with caustic soda; (3) Treatment with cleansing water.



Construction work being carried on by Foster Wheeler at Ancap's refinery in Uruguay: the cracking unit.

The kerosene treating unit has a mixer of 138 cu. meters operating load capacity and a full capacity of 250 cu. meters. It is equipped for the treatment of kerosene by loads, at the rate of one load each 24 hours.

It is supported on steel columns adequately protected against fire and is reached by a staircase. It is provided with loading and re-circulation pumps, gauge tanks, blow-cases for fresh sulphuric acid, for caustic soda solution, residuum and sludge decanting.

This unit is housed in a steel frame building, constructed of rubble work, of sufficient dimensions to contain the circulating pump and motor, the blow-cases and the gauge tanks for acid and soda. This building has also a storage chamber to contain a stock of caustic soda in drums.

The central chemical station has a capacity for preparing the following amounts of chemical solutions, per day of 24 hours, to be used in the alkaline treating unit: regenerated doctor solution, six cu. meters; new doctor solution, six cu. meters; caustic soda solution, 20 cu. meters. The station will have a storage tank for sulphuric acid and an installation to neutralize the spent acid with the spent soda.

This unit is equipped with pumps which will be interchangeable, that of the doctor solution with that of caustic soda and those of the sulphuric acid so that they can make suction from the tank zone.

The gas holder and gas distribution system will consist of a gasometer of 500 cu. meters capacity, at a water column pressure of 0.6 mt. and a gas washing station with caustic soda and water. Furthermore it includes the piping, from the washing station, which is situated alongside the cracking unit, to the gasometer and from the gasometer to the various points of consumption of low pressure gas, as well as the high pressure gas piping from the cracking unit to the power station. The gas washing plant, situated near the cracking unit, will be composed of a tower for washing the gas, tanks for the supply of soda, gaugers and pressure indicators.

The steam generating unit consists of three boilers, each with normal capacity of 3,300 kgs. of steam of 13.5 kgs. per sq. cm. and 250 deg. C. per hour and maximum of 4,000 kgs. per hour; a water treating station of capacity corresponding to two boilers working normally; an air compressor of 1,000 cu. meters capacity per hour at seven atmospheres, worked by electric motor, and the complete equipment for the alarm system against fire in the refinery, with 10 alarm boxes.

The boilers are from Babcock & Wilcox, of W.I.F. type, each one with 170 sq. mts. heating surface to stand a work pressure of 14 kgs. per sq. cm. complete, with supports and water supply regulators. Each boiler will be equipped with an integral super-heater to increase the heat generated to a final temperature of 250 deg. C. under normal working conditions.

This unit has a complete equipment of gas and fuel-oil burners, fuel-oil economizer; feeder pump; discharge tank; concrete chimney 45 mts. high; fuel-oil tank; automatic water treating station and air compressor. The foundations are covered with bricks and refractory clay.

The main pumphouse includes the assembly of pumps and piping in a suitable building. The pumps are as follows: two for fuel and residuum; two for gas oil; two for kerosene; one for turpentine; one for aviation gasoline; three for gasoline.

The fire defense station includes the powder hoppers, the high pressure water pumps and the solution generators for the production of foam, installed in a suitable building. The capacity of this station is 14,500 liters of foam per minute, when powder is supplied to the generators at the rate of 170 kgs. per minute and water at the rate of 1,000 liters per minute. The installation is of the Foamite system.

The ANCAP is installing a transformer of 600 kw. situated near the power plant. Inside this plant the main switch for the connection of the external current of 6,000 volts, as well as the switchboard for the distribution line of 200 volts for power and for lighting are being installed.

Other Installations, Constructions, Etc.

BEFORE proceeding to plan the administration and laboratory buildings, it was necessary to solve several urban problems.

Therefore the access to the plants has

been studied, which includes a wide avenue that goes up to the storage plant. This avenue has been made wide enough to allow the heavy traffic taking place at present in the storage plant and which will exist in the refinery.

The stationing of the vehicles in a large open space has been foreseen, to allow the easy handling of them. Two controls have been planned for the centralization of this function, one at the entrance of the storage plant and another at the exit of the refinery.

The administration and laboratory buildings which are in modern style, have been so placed as to form, together with the storage plant, a harmonious whole, and they limit at the same time the space destined for the public.

The buildings are in two groups joined by a loggia and approached by a wide avenue. The laboratory, planned as a U, will have a central part destined for common use and rooms for chief employees. The left wing, destined for the daily analyses, will be directly accessible from the principal street of the refinery. The right wing will be equipped with the necessary investigation rooms. In the top floor a large library and special investigation analysis rooms will be installed.

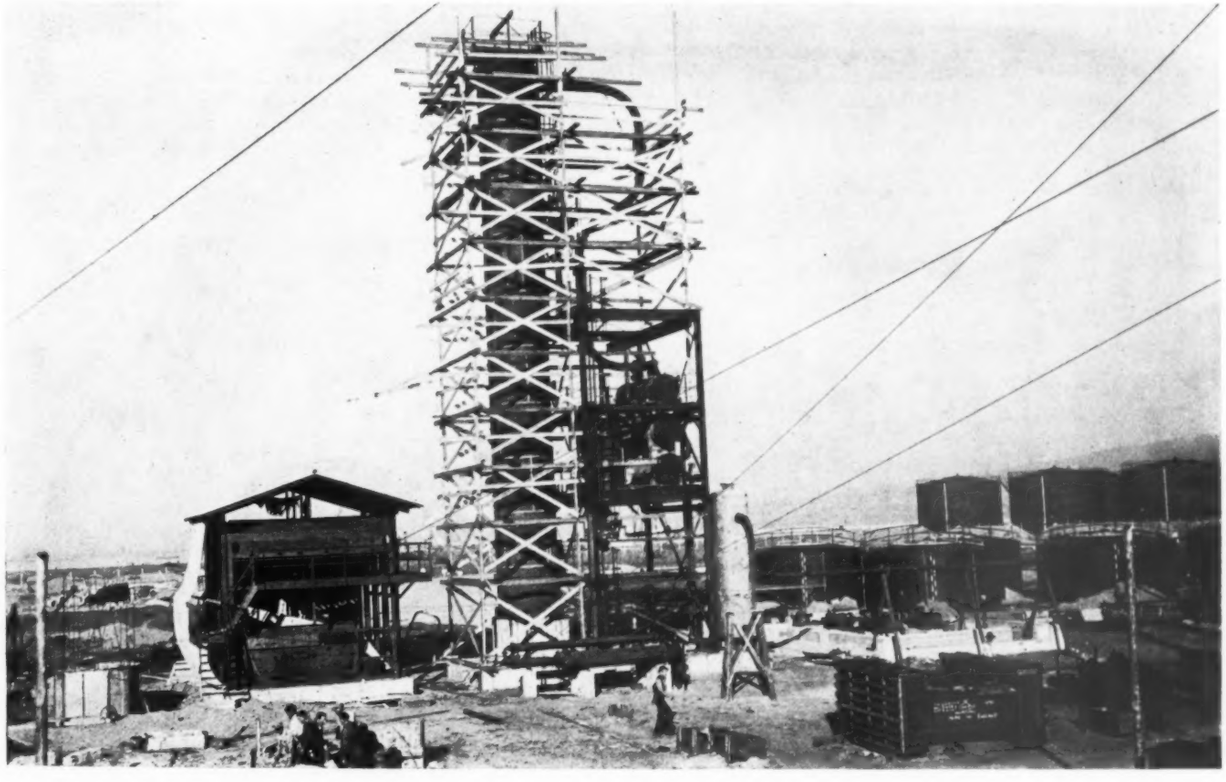
The administration building will be composed of two parts, one for the public and the other relating to the laboratory and plant in general.

General view of both topping and cracking units during construction in Uruguay.

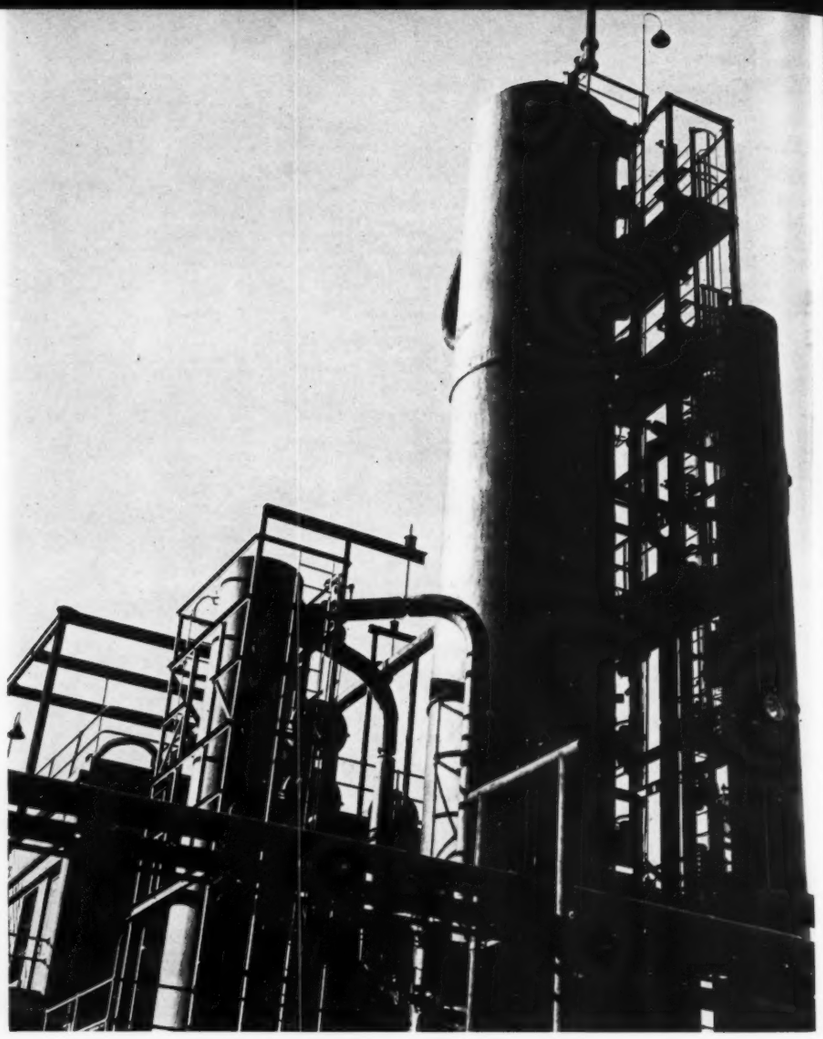
In order to facilitate the normal functioning of the refinery, buildings have been erected for the workshop and warehouses covering an area of 1,500 sq. mts., approximately. These have been constructed with concrete framework and rubble walls, and the iron framework roof is covered with non-inflammable asbestos cement.

At the head of the mole at La Teja, on Montevideo bay, a pump house has been constructed containing the pumps for the refrigerating water, this water to be taken directly from the bay. Alternative pumps will be used in cases of emergency by means of a double forcing piping for refrigeration and fire. The fire piping will also be connected with the storage plant central fire defense station, in order to increase its efficiency.

Close up of Ancap's topping unit under construction.



Solvent Refining In England



Solvent recovery tower in the Herbert Green Duosol plant.

WITHIN the past two years a new British lubricating oil refinery has been erected, and is now in operation, at East Halton, Lincolnshire, where, on a 53 acre site, the new scientific method of refining by Duosol solvent extraction and Double Solvent dewaxing processes is being successfully employed.

This refinery is the property of Herbert Green & Co. Ltd., and was built by British engineers, employing British labor, to designs prepared by the Lummus Company of New York, in accordance with American design and practice. It comprises industrial units capable of manufacturing lubricating oils of a high quality not made in Great Britain hitherto.

Under normal working conditions the plant is capable of producing approximately 40,000 tons per annum of finished solvent refined and solvent dewaxed lubricants of high viscosity index and it can also manufacture approximately 20,000 tons of medium grade oils, besides fuel oil, slack wax and other by-products.

When this enterprise was contemplated it was decided that British industrialists should be given the opportunity to manufacture and supply the plant and equipment. Although no engineering precedent was available in Great Britain for certain sections of the refinery, the decision has been justified by the manufacturers, who have contributed their share to the completion of the most modern lubricating oil refinery outside the United States.

Standing on the south bank of the River Humber, the main process units of the refinery are built upon a concrete mat covering 11 acres.

A junction connects the London & North Eastern Railway to a siding one mile in length, the property of the refinery. A jetty extends into the river for about 690 ft. at which tank barges can be dealt with at all tides. The refinery area is lighted at night by high powered electric flood lights together with light standards along the roads and around the storage tank areas.

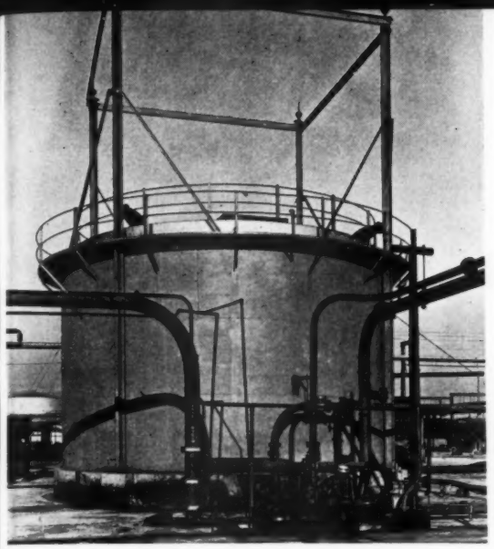
An idea of the size of the establishment may be obtained from the fact that the total length of piping throughout the refinery is about 51 miles. Except for the main cooling water line, which has a diameter of 18 in., and the oil lines at the transfer pump house manifold, piping for all services, including oil, solvents, fuel, steam, condensate, air and water, is carried overhead on over 600 pipe supports and eight structural steel bridges. Nearly 21,000 pipe fittings are incorporated in the system.

In common with other up-to-date refineries the plant has its own direct pipeline connection with ocean going tankers, facilities being available for pumping direct to and from tankers berthing at the Admiralty pier at South Killingholme.

Incorporated in the buildings and foundations are nearly 30,000 tons of concrete and about 1,000 tons of reinforcing and structural steel, while corrugated sheeting comprises an area of about 145,000 sq. ft. There are 700 tons of towers, process and work tanks, and 600 tons of other machinery and equipment. All piping and vessels for hot liquids are asbestos or magnesia insulated, while piping and vessels for refrigerated liquids are insulated with cork and wax.

The company has recruited a staff of British operators, chemical engineers, chemists, power engineers, and electricians. Many of these men were engaged throughout the erection of the plant and

[Since this article was written, it has been announced in London that a receiver has been appointed for the Herbert Green Company: this, of course, in no way diminishes the interest of a technical and purely descriptive article on the plant which is presented herewith—*Editor*]



Above: inert gas storage tank.

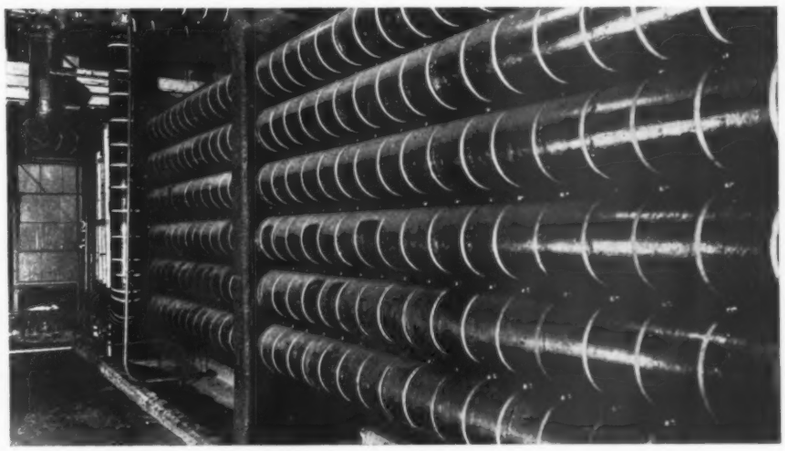
The paraffinic and naphthenic streams leave the extraction system at opposite ends. They are pumped to separate fusion welded evaporators where the major portions of the propane are removed by heat exchange and then recovered for re-use. The paraffinic and naphthenic layers are pumped through separate systems of heat exchangers, in which the heating mediums are hot oil and solvents, to the oil heaters or tube stills.

The system of exchangers and condensers comprises nine units with a combined duty of 71,977,000 B.T.U. per hour.

After passing through the heaters the respective streams are pumped to independent selecto recovery systems which incorporate fusion welded vessels. The vaporized selecto is rectified in a separate tower before its return to the process work-tank, while propane in the gaseous state is liquefied by compression and cooling. The oil streams are pumped to run-down tanks, the paraffinic oil going on to the next stage of the process.

The Duosol pump house, divided into three equal sections, shelters respectively the propane compressors, oil pumps and solvent pumps.

Two steam-driven Cooper-Bessemer compressors handle the gaseous propane in the propane-recovery system, one compressor being a standby when running at normal condenser water temperatures.



Right: Exchangers in the chiller building.

thus have had the advantage of working in conjunction with American operators with Duosol refining experience during the initial operating period of the refinery.

The Duosol system of refining consists of separating the paraffinic oil in the crude from the naphthenic tar by means of two solvents, liquid propane and "selecto". The solvents flow counter-currently, under pressure. Propane selectively retains the paraffinic constituents, precipitating asphaltic compounds, while the selecto solvent preferentially extracts the naphthenic fractions. This process is effected in a system of eight extractor vessels of welded construction and by motor driven pumps. All these vessels are designed to withstand a test pressure of 578 lbs. per sq. in., though the operating pressure is only approximately 300 lbs. per sq. in.

General view of the Herbert Green Plant at night.

Process rundown tanks.

The Duosol pump room houses 10 oil pumps, eight steam-driven and two operated by 45 h.p. motors. Five pumps, four operated by motors from 85–100 h.p. and one steam-driven, are provided for dealing with the two solvents.

The paraffinic oil is treated with activated bleaching clay in order to bring the color of the oil to final product specification.

The clay is conveyed from the storage building (capacity about 300 tons) by a bucket elevator, to an overhead clay storage bin of 700 cu. ft. capacity. From the bottom of the bin the clay is fed to a Poidometer conveyor and thence to the slurry tank, where it is mixed by motor operated gear agitator with the oil. This mixture, together with the main stream of oil, is circulated through a convection heater and pumped to a foam tank and a charge surge tank. The oil and clay are separated in three Sweetland filter presses under a pressure of 50 lbs. per sq. in. Each filter press has a filtering area of 522 sq. ft. The clay is dumped from the presses into cars on the floor below and the filtered oil is pumped through a cooler to the run down tanks or direct to the dewaxing unit.

It is a characteristic of the acetone-benzol solvent method of dewaxing that the oil produced is almost wax-free while the wax obtained is of a relatively high melting point and in consequence is more valuable as a by-product.

The waxy oil, after contact filtration, is dissolved in the mixed solvents, acetone and benzol. It is then pumped through a system of five double pipe exchangers with a combined duty of 2,500,000 B.T.U. per hour, having as a cooling medium the oil-solvent mixture, already dewaxed, which enters the exchangers at a temperature of −5 deg. F. The temperature of the liquid in the inner pipes is thus reduced from approximately 100 deg. F. to 40 deg. F. From these exchangers the mixture passes to five double pipe chillers, with ammonia as the chilling medium, and the temperature is further reduced from 40 deg. F. to approximately −10 deg. F. The surface area of the five heat exchangers and five chillers is 6,850 sq. ft. each.

Special mention must be made of the refrigeration compressors. These are two horizontal duplex-double-acting, two-stage steam-engine-driven, ammonia compressors, capable of providing 225 equivalent tons of refrigeration per day at −30 deg. F. at the chillers. The steam engine for each compressor operates at 115 lbs. steam pressure. There is a common surface condenser capable of condensing all steam from the ammonia compressors and the propane compressors of the Duosol unit.

The waxy oil and solvents, at the reduced temperature of approximately −10 deg. F. are pumped under pressure to four Vallez rotary leaf filter presses, each having a filtering area of 800 sq. ft. The wax is retained on the filter leaves while the oil solvent mixture passes through the leaves to a surge tank. The wax cake after washing with chilled solvent is dislodged by inert gas and discharged to a spiral conveyor and transferred thus to a wax surge tank. The solvents are recovered from the pressed oil mix and from the slack wax mix in separate systems of heat exchangers and evaporating towers.

The solvent recovery plant of the dewaxing unit consists of four evaporating and fractionating towers varying from 35 ft. to 40 ft. high, and 16 exchangers, condensers and coolers with a combined duty of 20,672,600 B.T.U. per hour, and having a total surface of 8,323 sq. ft. To facilitate solvent recovery without overheat treatment, a special high-pressure boiler producing steam at 410 lbs. per sq. in. is installed. The boiler operates in a closed system with a small amount of make-up consisting of clean condensate from 125 lbs. steam. The vaporized solvents are condensed and returned to the solvent work tanks or to storage, while the dewaxed oil is pumped to storage or rundown tanks.

The dewaxed oil is now fully refined, and ready for marketing. In special instances it may be subjected to vacuum distillation to produce specification products.

The distillation unit consists of a vacuum tower 57 ft. high, the upper portion, 40 ft., 6 in. long, having a diameter of 8 ft., 6 in. and the lower end a diameter of 4 ft. The tower has 16 decks.

Operated by five steam pumps and equipped with five heat exchangers with a combined duty of 11,298,000 B.T.U. per hour, and four process tanks with a total capacity of 600 cu. ft., the vacuum

distillation unit can be set to produce various fractions from the product of the dewaxing plant.

The unit may be used for adjusting the specification of the crude residuum according to the requirements of the market for neutrals, bright stock and other products.

The plant is also equipped for the manufacture of oils having low demulsibility for special purposes such as for use in turbines and steam engine crank cases. The specification stock is given a light clay treatment and for this purpose two clay towers, each 12 ft. in diameter and 18 ft. high, with conical bottoms, are used.

In addition to the Duosol refining units, the company is provided with facilities for manufacturing medium grade machinery oils by atmospheric distillation. This unit comprises distillation tower, tube still, pump house and process tanks. The capacity of the unit is about 55 tons of lubricating oil per day, besides gas oil distillate.

The blending and barrelling plant is housed in a steel frame building 236 ft. long by 26 ft. wide, and is equipped with patent drum filling and weighing machines. Adjoining it is a loading platform 230 ft. long on a steel structure equipped to fill 10 rail and 10 road tank wagons simultaneously, while road tank wagons can be loaded by gravity in an adjoining bay direct from the blending plant. There is storage for 1,000 filled barrels as well as 1,200 empty barrels.

The arrangements for blending are excellent. The layout of blending and mixing tanks is well designed and enables small and large blends to be made to specification.

One of the most important units in the refinery is the oil transfer pump house which is equipped with nine steam operating duplex pumps and controls the transfer of oils throughout the plant through a manifold of 58 separate 6 in. lines. Provisions have been made for extension of pumping services to meet any future requirements.

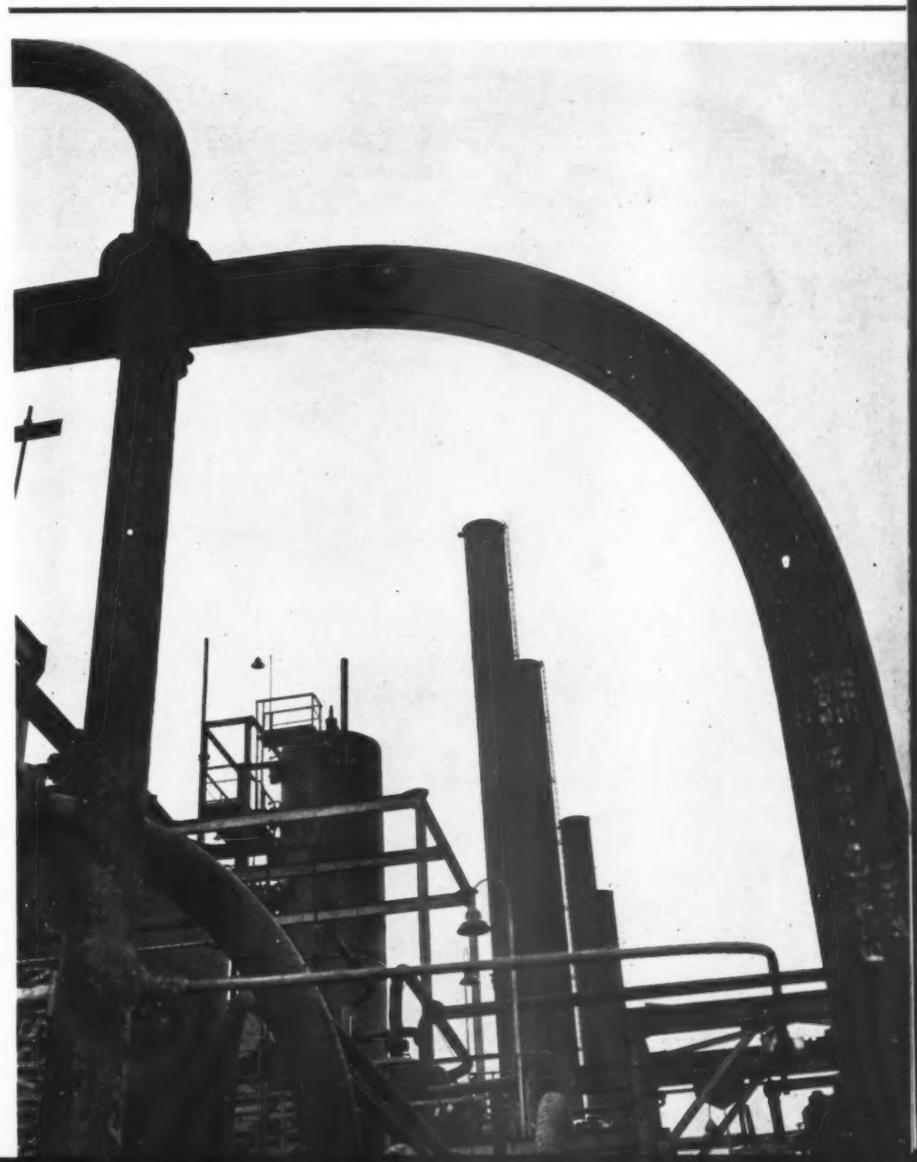
The refinery is equipped with six oil-fired heaters and a steam superheater for the purpose of heating the oil and solvents at different stages in the process, the range of temperatures varying from 100 deg. F. to 750 deg. F. The total heating surfaces of the combined heaters is nearly 10,000 sq. ft.

Electrical energy for the refinery is supplied by two independent high power cables of the Grimsby Corporation's electricity department, one of 22,000 volts, the other of 11,000 volts. From the corporation's transformer station within the refinery boundary, the supply becomes 11,000 volts, and is transmitted to the company's main sub-station, where the current is reduced through two transformers to 400 volts for power and 200 volts for lighting. All motors, control gear and lighting equipment are of the spark proof type, and transmission is through spark proof and weather proof switch gear to the various operating units. The number of electrical motors installed is 132, with a total of 1,600 h.p. Some conception of the size of the system and the vital importance of the electrical installation will be obtained when consideration is given to the fact that it incorporates four miles of underground power and lighting cables, and 3½ miles of electric overhead lines. The layout of the installation is admirable and reflects great credit upon those responsible for the work.

The steam service is supplied from oil-fired boilers having a capacity of 65,000 lbs. per hour, at a working pressure of 125 lbs. per sq. in. The auxiliary plant comprises four boiler feed pumps and water softener, a condensate return tank, oil eliminating plant and two fuel oil tanks, each having a capacity of 3,600 gallons.

Fresh water for boiler feed and other purposes is obtained from a well sunk to a depth of 300 ft. The pumps, which are electrically operated, have a capacity of 10,000 gallons per hour. The elevated reserve storage tank has a capacity of 30,000 gallons.

A lake covering 18 acres on the northern boundary of the refinery is available for circulated cooling water. By means of two horizontal, double-suction, centrifugal, turbine pumps, the lake water can be pumped at a rate of 6,500 gallons per minute to the circulating system through an intake pipe of 36 in. diameter. During full operation the stream flowing in the effluent channel amounts to nearly 180 tons of water per hour. Any waste oil mixed in the return stream is separated in skim tanks before the water is discharged into the lake. A chlorination plant is



Detail of the Green Duosol plant.

installed to prevent the growth of algae in the cooling water system. Duplicate turbine pumps similar in power to those used in the water intake pumphouse are available for the maintenance of high rates of flow when necessary.

The compressed air requirements of the refinery are supplied by two motor-driven compressors. The main compressor, driven by a 165 h.p. motor, has a capacity of 800 cu. ft. per min. and the stand-by unit is a two-stage compressor, being actuated by a 57½ h.p. motor. Three air receivers, with a combined capacity of 450 cu. ft. complete the main compressed air supply system. A number of smaller compressors deal with auxiliary air supply for operation of control instruments throughout the plant.

Steam boilers, superheaters and tube-stills, are fired with fuel oil. The fuel oil system forms a continuous loop throughout the plant, the supply lines linking the various heating units with fuel storage tanks.

The inert gas system forms part of the dewaxing plant, for which a constant supply of inert gas must be maintained. The inert gas is produced by the combustion of Diesel oil in a generator fed with air by a Roots blower driven by a 1½ h.p. motor. The generator is capable of delivering a maximum of 3,000 cu. ft. per hour of inert gas at 100 deg. F. to a gas holder having a capacity of 10,000 cu. ft. Inert gas is necessary to maintain the pressures in the solvent tanks for the operation of the Vallez filter presses, and to prevent the possibility of formation of air-solvent vapor mixtures in the vessels incorporated in the dewaxing unit.

The refining operations of the plant are automatically controlled and regulated by the most up-to-date instruments and recorders. They are of vital necessity in the maintenance of correct pressures, temperatures and rates of flow in the various process units. They are all automatic in action and many of them make permanent records of the operations on specially designed charts.

The refinery installation includes 28 storage and run-down tanks, having a total capacity of over 47,000 tons. Four of these tanks are available for the reception of crude oil. Most of the tanks are fitted with steam heating coils.

The Duosol refining plant has a battery of seven horizontal tanks for the storage of its solvents—liquid propane and selecto solvent. Three of these vessels, of welded construction, have been tested to 424 lbs. per sq. inch, the four smaller vessels being hydrostatically tested to 20 lbs. per sq. in. Four of these storage tanks have a capacity each of 20 tons of liquid solvent.

The solvents used in the dewaxing process are acetone and benzol, for the storage of which four fusion-welded tanks are provided, each having a storage capacity of 20 tons. Two other fusion welded tanks, tested to a pressure of 390 lbs. per sq. in. at a maximum temperature of 105 deg. F. are used for storing ammonia in the refrigerating plant.

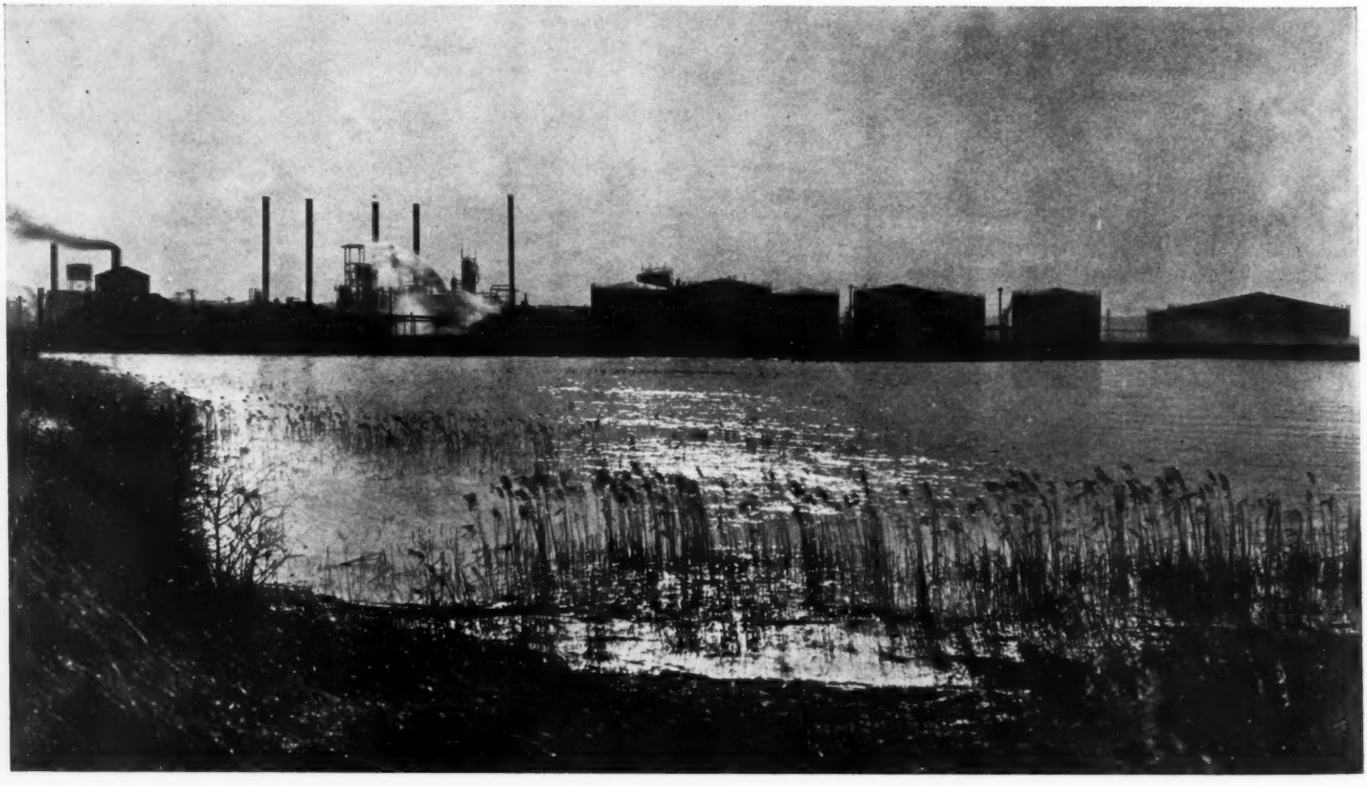
For the adequate maintenance and repair of the refinery equipment stores and workshops have been provided. These include a machine shop, with electrically operated machines, pipe bending shop, carpenters and electricians shop, and riggers and paint stores.

Special attention has been paid to fire protection. A separate system of underground water lines comprises 28 two-way fire hydrants. Three steam duplex pumps with a total capacity of 900 gallons per minute situated in the water pumphouse are detailed for fire service.

Foamite lines with two-way headers are fixed to all storage and run-down tanks. The areas around the largest storage tanks are protected by earth fire dykes.

There is a main fire station at a central point in the refinery with headquarters for the fire alarm system. It is equipped with fire carts, hose, foamite generators, portable foamite extinguishers, and a reserve stock of foamite. At strategic points in the refinery are four sub-stations, similarly equipped. Asbestos suits, respirators, and breathing apparatus are available and hand extinguishers are provided in all buildings and hazardous areas. Fire-proofing is carried out on all supports for vessels containing inflammable material and insulation on vessels and hot oil lines.

(Continued on page 560)



Foreign Oil Legion

Wilson Cross, for many years head of the Vacuum Oil Company interests in Great Britain, sailed from England for the United States on the MANHATTAN October 22nd. Mr. Cross, who retired recently, plans to make Beverly Hills, California, his future home. His many friends in the oil industry are advised that he can be reached care of the Masquers Club, Sycamore Street, Hollywood, California.

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Robert B. McColl

Robert B. McColl, who was until recently vice president of the American Locomotive Company, Diesel Engine Division, has been elected president, member of executive committee, and director of Alco Products, Inc. He succeeds Mr. Joseph Davis whose resignation, due to ill health, was accepted last month.

Mr. McColl was born in 1882 at Kilmarnock, Scotland, where he attended the Kilmarnock Academy and the Science and Art College. He became attached to the New York office of the American Locomotive Company in January, 1922, and the following June was appointed assistant manager of the Schenectady plant, and in January, 1925, manager of the plant. In 1931, he was elected president and director of the McIntosh & Seymour Corporation, Auburn, N. Y., a division of the American Locomotive Company. Recently, when the McIntosh & Seymour Corporation was merged with the parent company, Mr. McColl was appointed vice president of the American Locomotive Company, Diesel Engine Division, which position he held at the time of his election as president of Alco Products, Inc.

Mrs. Beryl Markham, the first woman successfully to complete an east-to-west solo flight across the Atlantic, was given a luncheon at the Savoy Hotel, London, by the chairman and directors of the Anglo-American Oil Company, Ltd., on October 1st. Anglo-American's chairman, Frederick J. Wolfe, was one of the speakers.

J. C. Hilton, who recently resigned as president of the Standard Oil Company of Louisiana, has been appointed vice-president of the Standard Oil Company of New Jersey (Del.) and will assist F. W. Abrams, president.

Dr. Lazar Edeleanu, a pioneer of solvent refining in the petroleum industry, celebrated his 75th birthday on September 14th. Dr. Edeleanu invented the sulphur dioxide process for the refining of petroleum products in the course of the research work he conducted in Bucharest, Roumania, in the years between 1900 and 1910 as director of the Royal Geological Institute. In 1910 he assumed the management of the Allgemeine Gesellschaft, and in this capacity he commercially developed his process with the result that over 40 Edeleanu installations have carried his name all over the world.

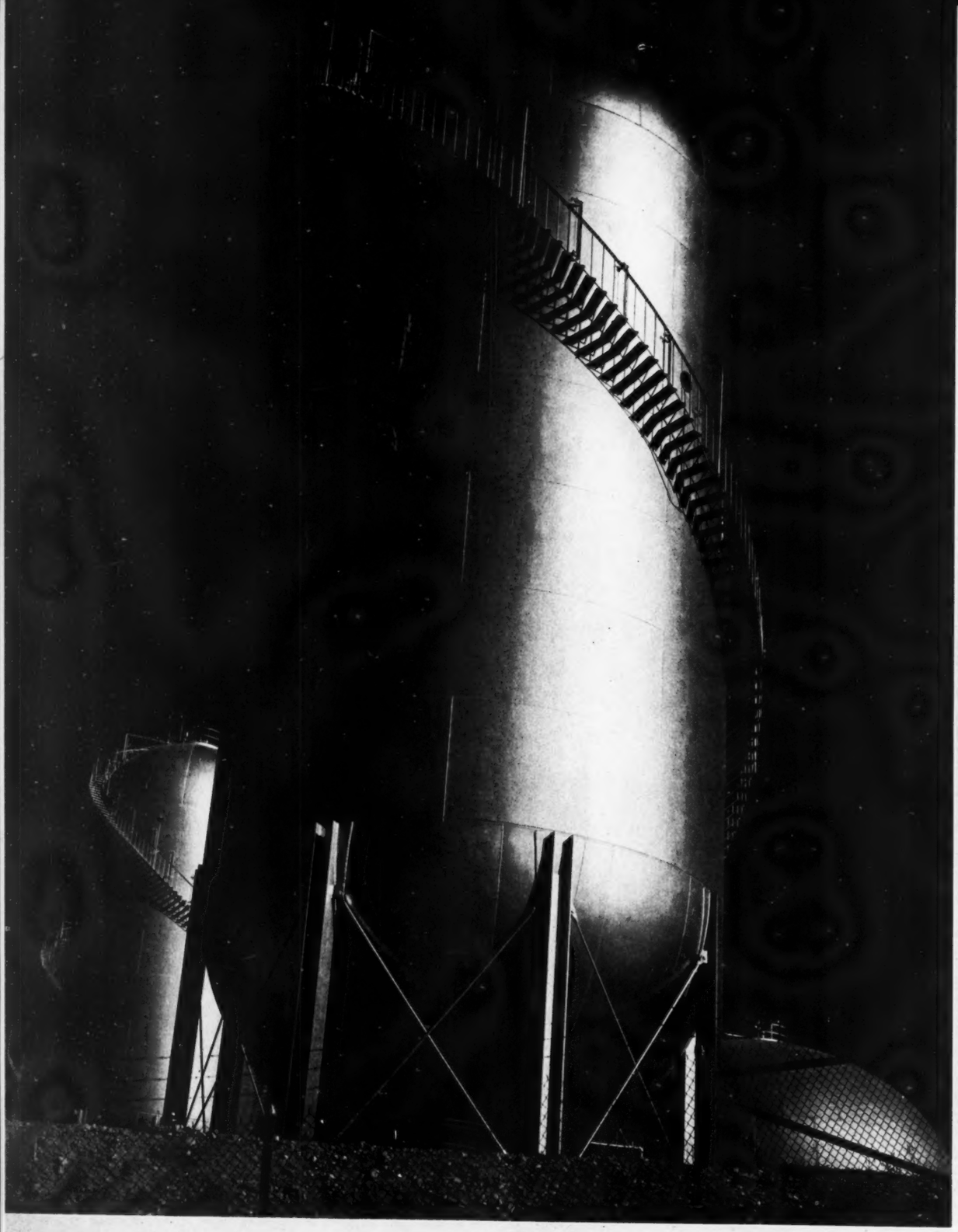
Dr. Edeleanu has received many honors for his scientific work and his industrial accomplishments. In recognition of his merits for the cause of the oil industry, the Institution of Petroleum Technologists, London, awarded him the Redwood medal in 1931. He retired from the management of the Edeleanu Gesellschaft and American Edeleanu Company in 1931, and has since been living with his family in his native city of Bucharest. Enjoying the best of health, Dr. Edeleanu is still highly interested in everything concerning the oil industry.

Charles F. Kettering

Charles F. Kettering, technical director of General Motors Corporation, is visiting England and the Continent, together with George Codrington, president of Winton Engine Company. A great amount of research work on lubricating oils and gasolines, both in motor-vehicle service and under laboratory conditions, has been carried on by General Motors under the direction of Mr. Kettering, and the company is now turning its attention to production of Diesel engines for vehicles.

Some years ago General Motors spent about $2,000,000 in high-speed Diesel engine research work, the outcome of which was found invaluable when the Winton Engine Works was acquired. Many of the famous oil-electric trains have been powered by them.

George Codrington



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Russian Refining

by J. Wegrin

OF THE three main divisions of the Soviet oil industry, Soviet refining today presents the most advanced and progressed unit. This is due to the fact that drilling and production, though reconstructed, modernized and equipped previous to 1928 (the beginning of the First Piatiletka) have remained more or less at the same level of efficiency ever since. The refining division, since its reorganization during the First Piatiletka has kept pace with modern requirements. Subsequent to 1924, when the old type shell stills were rebuilt, modernization and enlargement have been continuous. Effective evaporators and towers were introduced, followed by modern furnaces and pipe stills. Electrical devices, precision instruments, power pumps and modern treating facilities have been added year by year.

Even in 1932, after the Soviets had practically stopped importing equipment from abroad, the importation of refining equipment was nevertheless continued. Besides, the Soviet engineering mind has proved more ingenious when thinking in terms of refining than in terms of drilling and production.

Divided into periods the Soviet refining industry has progressed as follows: (Up to 1924) Old type shell stills and their modernization. (1924–28) Advance to pipe stills. (1928–31) Cracking installations. (1931–34) Combined Cracking (two furnace systems). (1934–35) Modern lube oil treating. (1935–36) Selective treating of lube oil and gas polymerization. Today the Soviet oil industry is aiming more and more to tie up its operation with chemistry.

Before the Soviets nationalized the oil industry Soviet refining consisted mostly of primitive shell stills for the processing of crude and fuel oil and old type mixing devices for treating gasoline, kerosene and lube oils by means of acid and neutralizers. Almost all of the equipment in use was superannuated, usually small-scale units necessitating complete individual installations and often duplicating one another to a large degree.

All this was eliminated during the first reorganization, preparing the way for large, centralized refineries designed and erected along the lines of the most progressed technique. Several score of refineries at Baku were demolished, rebuilt and centralized under groups such as Stalin, Piatakov, Djaparidze, Budenni, etc., and modern refinery plants were erected at Batum.

At Grozni there were comparatively few refineries in existence before modernization set in. Grozni and Tuapse, therefore, possess even finer facilities, practically all units being of entirely new and modern construction.

The Stalin group consists of seven huge vacuum stills with 16 Sweetland filter press units which form a powerful combination for obtaining deep cuts of light fractions.

Percent Light Products (Gasoline, Kerosene & Ligroin) Obtained at Stalin Group

Year	Percent Yield	Percent Light Products
1921–22	26.0	–
1923–24	31.4	–
1924–25	33.3	–
1926–27	38.8	–
1927–28	32.0	–
1931	28.4	79.6
1932	27.2	63.1
1933	30.5	69.4
1934	34.2	78.9
1935	35.7	76.3

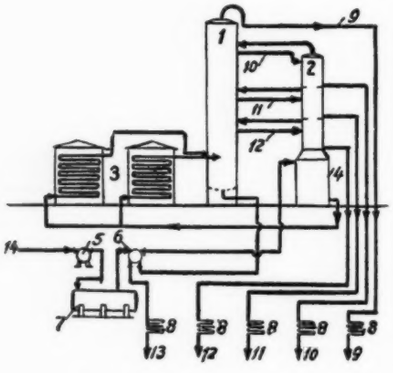
After cutting of light products and lube oil from asphaltic base crude, the remain-

© Sovfoto

Yaroslavl-Konstantinovka refinery built several years ago.

ing 14–16 percent of residues are processed for asphalt in grades ranging from road bitumen up to asphalts used in the rubber industry. Paraffin base crude is cut for light products and the residues undergo cracking.

Among the outstanding features of the new equipment introduced are: turbine compressors of a capacity of 4,000 cubic meters per hour; pressure pumps of 20–25 atm. when temperature of the liquid is at 300 deg. C.; turbine mixers of high revolution to maintain the weighted volume of clay in the mixing oil; ejectors of discharging capacity of 50 mm. and below absolute mercury pressure; motors safe against explosion when operating in gasoline vapors.

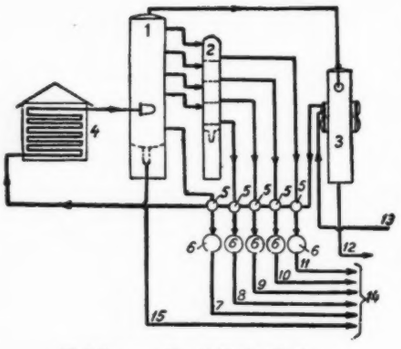


New Soviet Pipe Still Installation.

Dirt, lakes of residues, holes in the ground used as storage and all sorts of miniature mixing and refining installations have all disappeared to make room for huge refinery units, some of which are of Soviet domestic design and manufacture, while others are imported units such as Graver, Badger, Foster Wheeler, Alco and others. Asphalt roads, lined with trees, have replaced the former mud paths and the former territory of Baku refineries has now been considerably extended.

Many innovations previously unknown to Baku refineries have been introduced. Refining with calcinated soda has made possible the production of completely neutralized distillates directly from the installations, and so doing away with all separate neutralizing equipment. Acid regeneration from residues by means of electricity or contact filtration in lube oil treating plants has made possible the processing of 250 tons of residue per day to yield 40–50 tons of reclaimed acid of 65–80 proof.

Further modernization and new erections have been going forward during 1936, of which two new pipe stills for 3,000 tons capacity per day together with a



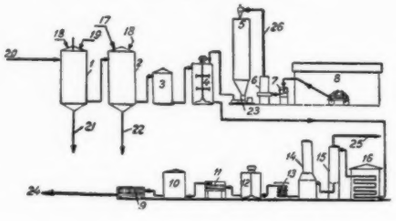
High Vacuum Pipe Still Alco Products.

selective treating installation for lube oil (Furfurol) are noteworthy. Iron and cast iron have been discarded in construction and replaced by high quality alloys (addition of chrome nickel, vanadium, etc.) in order to prevent all possible corrosion; these alloys are also used for making valves. Electric and auto welding is now being used in all repair shops.

The Piatakov group of refineries was similarly rebuilt from many installations formerly owned by Nobels, Gukassoff and others. These were all small units of ineffectual operation owing to high fuel consumption and low quality of the end products. There were, altogether, 21 refining units, some of small and some of larger capacities scattered over a wide area. These refineries had handled over 50 percent of the total Baku refining capacity. At the time of nationalization, however, only 10 installations were on stream, but between 1921 and 1925 all shut-down plants came on stream.

In 1927 all shell stills were modernized and rectification towers added. The straight-run yield capacity was increased from 20 percent of the potential in 1925 to 70 percent of the potential in 1927, thus freeing the plants from unnecessary losses and high fuel consumption under secondary re-run. In 1926 the first pipe stills were erected. L. D. Nersessov designed and built his first furnace for a capacity of 160 tons per day and following this four more stills were installed. A 10-shell still battery for lube oil was also erected (design by Hershgorn & Zadolin). Also in 1928 a large kerosene treating plant was

Lube Oil Treating Plant—4 Sections.



built. In 1929 three more pipe stills were erected. Two more were erected in 1930 and 1931. In 1932 a lube oil treating plant came on stream in line with a large high vacuum pipe still (plate tower) of domestic design and construction. Thus in 1932 the first reconstruction was completed. The through-put capacity has so far exceeded the capacity of 1921 and the yield of light products from the crude potential has increased from 26.7 percent to 28.5 percent for crude and from 22.0 to 35.1 percent for fuel oil.

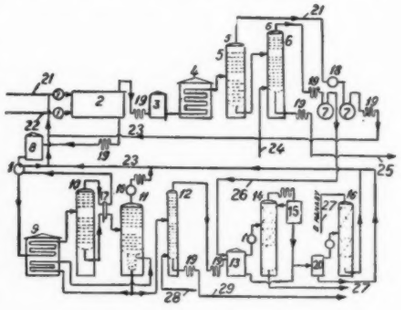
Piatakov Group — Operation Statistics

	Average monthly figures	
	1933	1935
Runs to stills (1,000 tons)	381.5	455.9
Cut light products (percent)	31.4	33.03
Processing of residues (1,000 tons)	85.15	64.0
Cut viscous products (percent)	28.05	34.8
Cut light products up to 315°C.	23.5	25.5
REFINERY YIELD		
Gasoline (1,000 tons)	10.34	11.79
Kerosene "	147.1	213.43
Lube oil "	25.0	19.7*

* Decrease due to transfer of one shell still battery from this group to Djaparidze group and demolition of one lube oil battery.

Consequently, during the second Piatiletka the Soviets were able to give more attention to important problems of operation and quality and in doing so the Piatakov group of Baku plants has become foremost among modern installations. The erection of 9,000 tons of pipe still capacities at the Piatakov group has changed the ratio of pipe stills to shell stills from 20 percent in 1932 to 54 percent at the beginning of 1936.

Soviet Installation Selective Lube Oil Treating.



Djaparidze Plant or Lube Oil Treating Installation (MOZ) consists of four sections of Max Miller lube oil treating plants; the first and second sections being erected in 1933, and the third and fourth sections in 1934. The treating capacity of each section is 450 tons of treated oil per day or a total of 150,000 tons per year, which places the plant among the largest of the world from the standpoint of contact filtration.

The two first sections, completed in 1933, operate as follows: First Section—Machine oil distillate charge from Badger high vacuum installation processes crude under calcinated soda and yields ash free distillates of low acidity. The charge is mixed with clay in proportions of three to four percent of weighted oil, then carried by pumps to the furnace to be heated and proceeds to evaporator and tower where it is met by superheated steam circulated by centrifugal pumps, then continues to Sweetland presses to absorb clay, after which follows secondary filtration by means of filter presses.

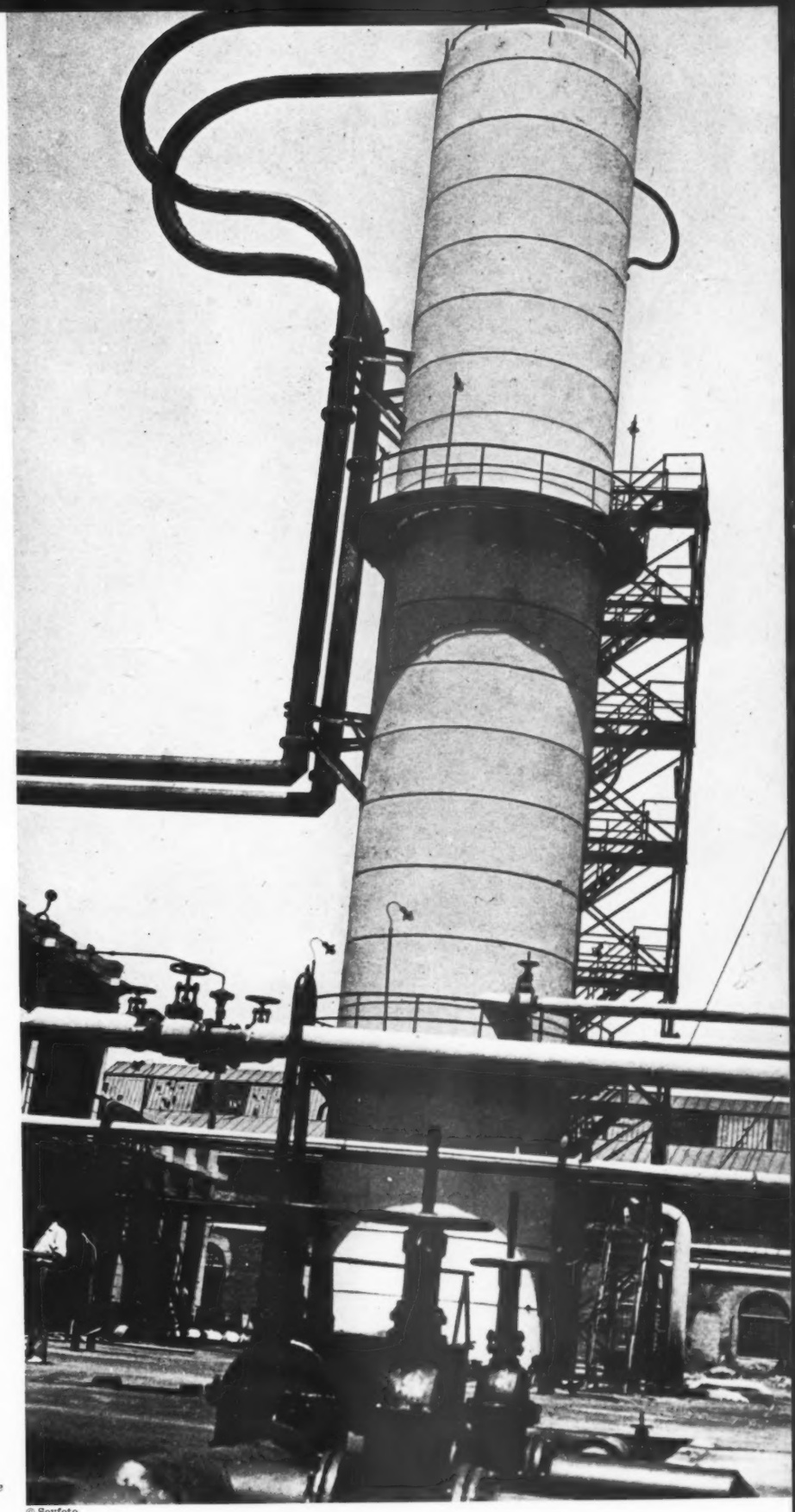
The second section treats cylinder oil distillates from the high vacuum Alco installations. The entire process is similar to the process of the first section with certain modifications which were necessary owing to the fact that Alco installations are operated without calcinated soda. Altogether there are five operations, namely: (1) concentration of residues to required viscosity, (2) treating of concentrate with sulphuric acid, (3) treating with bleaching earth followed by filtration, (4) dewaxing and freezing out of mixture oil and gasoline at 46 deg. below zero and Sharpless centrifuging, and (5) removing the neutralizer used in filtration under dewaxing.

Refinery Units Completed During 1936

Location	Number Units	Annual Capacity (bbl.)
PIPE STILLS		
Ufa	1	3,500,000
Baku	2	14,000,000
Neftdag (skimming plant)	1	1,400,000
Ishimbayevo	1	3,500,000
Orsk	1	3,500,000
CRACKING PLANTS		
Baku (one furnace)	4	2,950,000
Grozni (two furnaces)	4	7,000,000
Orsk (one furnace)	2	2,100,000
Saratov (two furnaces)	2	3,500,000
Moscow	1	1,275,000
Berdiansk	1	1,275,000
Kherson	1	1,275,000
Odessa	1	1,275,000

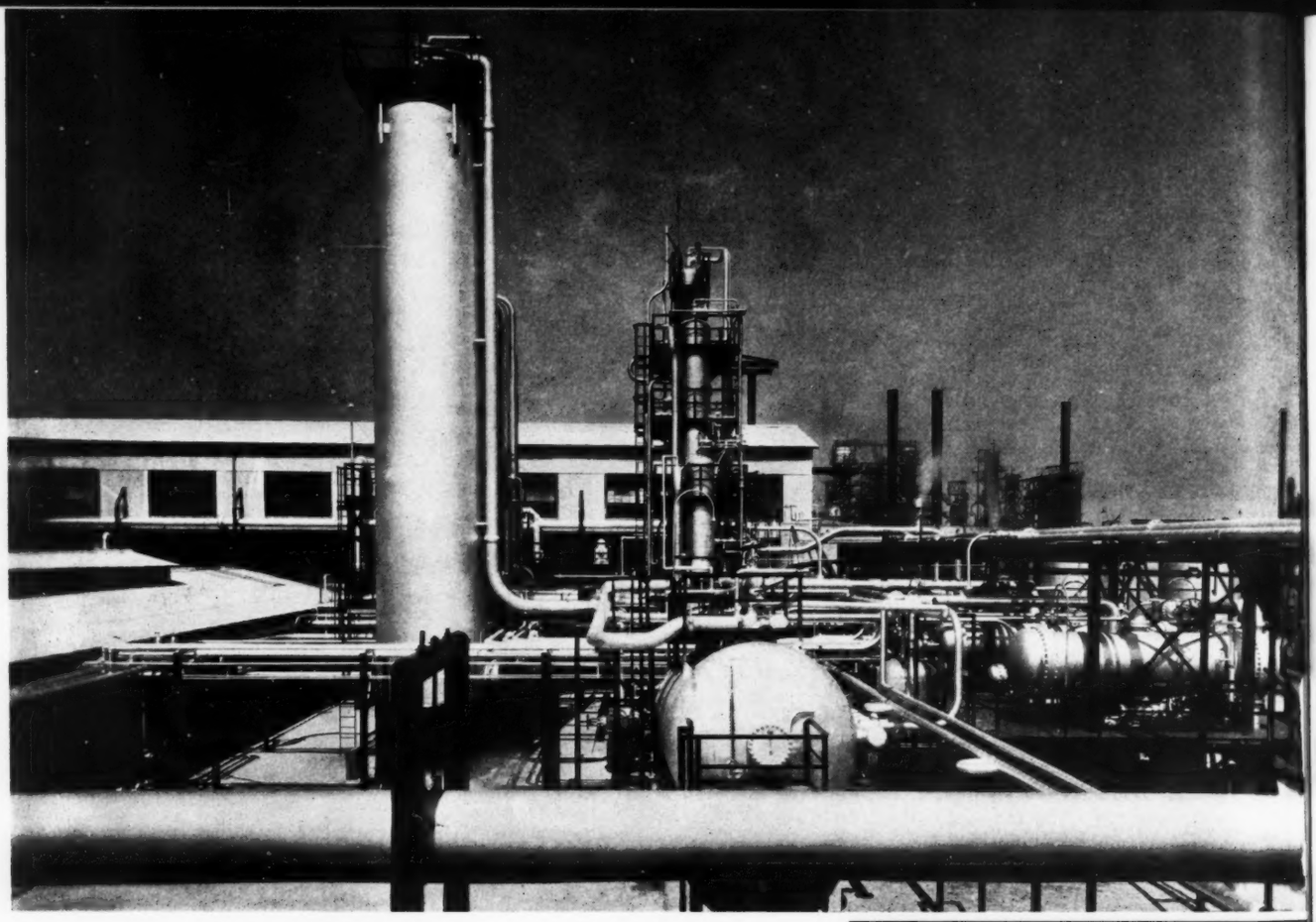
Recently new orders were placed with Max Miller for a contact installation and two installations for selective treating of lube oil, one Duosol and the other Barisol.

Out of the present total of 148 refinery units in the Soviet Union, the 22 units listed in the accompanying table were constructed during the current year (1936). Many of these are already on stream, but all are expected to be completed and on stream by the end of the year.



Part of a cracking unit in the Stalin refinery at Baku.

© Sovfoto



Roumanian Refining

ONE of the striking characteristics of the Roumanian oil refining industry is the fact that small enterprises, having little working capital and primitive equipment, are able to exist alongside of great corporations having every advantage of capital, modern equipment and skilled technical and commercial direction. In 1935 the country had a total of 62 going oil refineries operated by 54 companies, but 18 of these worked 98.16 percent of all the crude oil that was treated in that year, leaving only 1.84 percent for the 44 other establishments, and some of these small establishments are small indeed; 21 have capacities for handling less than 10,000 tons of crude oil a year. The total refining capacity in the whole country is 11,764,000 tons a year divided between large, medium and small refineries, as in Table I.

Over against the fact that the Roumanian oil refineries have a total capacity for refining 11,764,000 tons of crude oil a year stands the fact that the total production of refined oil products in 1935 did not exceed 8,138,000 tons (an all-time peak), which is 69.2 percent of the refining capacity. This would appear to indicate that the Roumanian oil refining industry is overbuilt. It seems strange that the capacity of the distilling plants should show an increase of 1,190,000 tons, and that the capacity of cracking plants should be enlarged by 146,000 tons in a single year (1934) without any notable

Table I. — Classification of Roumanian Refineries

	Companies	Refineries	Yearly Capacity Tons	%
Large	9	15	9,879,000	83.98
Medium	14	15	1,547,000	13.15
Small	31	32	338,000	2.87
Total	54	62	11,764,000	100.00

increase in refinery throughput. But there is a reason. In the first place there is little "free" crude oil in Roumania, that is, crude oil produced by independent oil operators, so that the refiners are limited largely to the product of their own oil wells. In the second place the refineries have pursued a policy of continual modernization of their plants with the object of increasing efficiency and lowering costs. The fact that this modernization has been accompanied by an increase of unusable refining capacity is an interesting result,

Forty three refineries capable of handling 822,500 tons, or 6.83 percent of the total, operate discontinuously with ordinary distilling equipment.

One refinery operating discontinuously in combination with pipe stills can handle 1,095,000 tons (9.16 percent).

Fifteen of the refineries using pipe stills only have a capacity for producing 5,096,500 tons of refined products (24 percent of the total).

Only five of the largest refineries have cracking plants; these are Steaua Romana,

Table II. — Growth of Roumanian Refining Industry

(in thousands of tons)

Year	Refining Capacity		Crude Oil Production	Crude Oil Throughput	
	Distilling Plants	Cracking Plants		Total	% of Capacity
1930	6,800	765	5,744	5,652	83.1
1931	8,400	834	6,657	6,577	78.3
1932	9,080	985	7,350	7,014	77.2
1933	9,837	1,059	7,387	7,285	74.0
1934	10,574	1,354	8,473	8,015	75.8
1935	11,764	1,500	8,382	8,138	69.2

but one of subordinate importance. The rate of this expansion during the past six years is shown by the accompanying Table II (in thousands of tons).

As would be expected in such a miscellaneous collection of big and little refineries there are varying degrees of modernity, as may be particularized as follows:

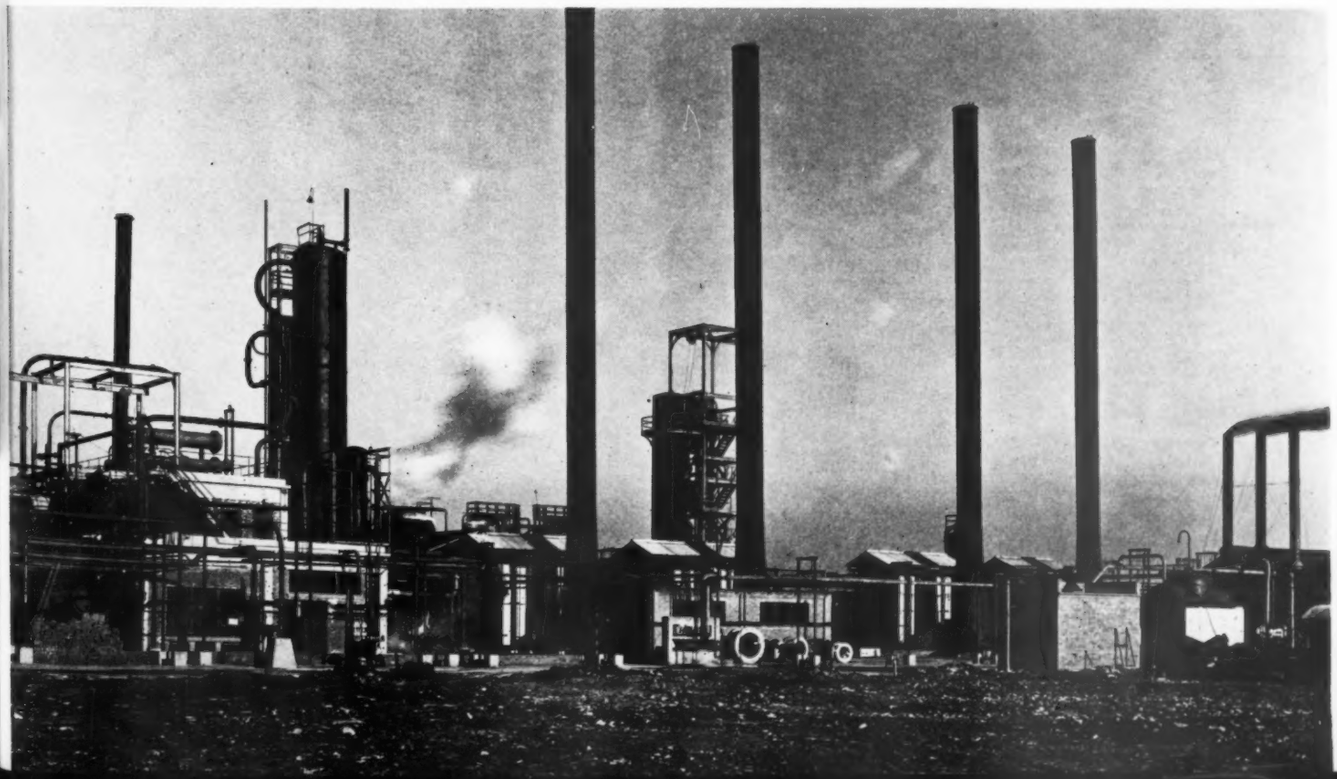
Eleven refineries have equipment of the ordinary type for the continuous distillation of 4,936,000 tons of crude oil; this is 41.31 percent of the total throughput.

Astra Romana, Romana Americana, Colombia and Creditul Minier. The cracking plants of these companies operated on 959,228 tons of charging stock and produced therefrom 265,953 tons of cracked gasoline. The total yield of gasoline from all sources in all refineries in 1935 was 22.78 percent of the crude oil employed; the combined yield of all finished products was 92.25 percent, as compared with 91.95 percent in 1934.

The greatest over-all yield of gasoline is naturally obtained by those refineries having cracking plants. The medium and small sized refineries, which are little more than skimming plants, obtain gasoline yields hardly amounting to 16 percent.

The Roumanian oil industry is predominantly an exporting industry and, moreover, is the backbone of the country's foreign trade. The part played by the refining industry in this trade is extremely important.

At top of the facing page is an illustration of Shell Petroleum Corporation's Wood River plant while below is shown the Herbert Green plant in England. The two labratory pictures are published through the courtesy of Standard Oil Development Co.



Germany Strives for Self-Sufficiency

Continually Greater Emphasis Being Placed on Hydrogenation of Coal by German Chemists — Motor Fuel Consumption Figures for 1935 Show Increase Over 1934.

By Dr. Paul Schwarz

Former German Consul
in New York

TODAY the German refining industry consists of 38 units which include all so-called "Benzine Fabriken" and asphalt installations. Some of the refineries are capable of processing intermediate distillates only, while others are used only for blending of gasoline. A scattered few are full-fledged refineries adjusted for crude runs to stills and are able to produce a full line of petroleum products. The total capacity of all German refineries aggregates 2,240,000 tons, of which six refineries operate about 495,500 tons of domestic crude per annum. The accompanying table shows the geographical distribution of German refineries.

According to FOLKSWITSCHFTLICHE CORRESPONDENZ, gasoline from hydrogenation of coal in Germany during 1936 will reach 600,000 tons (as against 550,000 tons in 1935) and benzol production for fuel purposes will amount to 430,000 tons. Germany has four methods of producing motor fuel by domestic means: (1) Coking at high temperature (benzol); (2) Hydrogenation process (Bergius); (3) Semi-coking at low temperature; (4) Fischer Tropsch synthesis of gases.

The Fischer Tropsch method is a process in which hydrogen is a predominating factor under eight different combinations of mixing the gases from coking. Rhur Chemie has a semi-industrial installation and plans to erect an installation with 250,000 tons annual capacity. Kloekner also plans to build a new installation with two furnaces of 1,000 tons per day capacity each.

German Domestic Consumption of Motor Fuel

	1934 (tons)	1935 (tons)
Gasoline:		
Domestic	250,000	365,000
Imports	1,030,000	1,405,000
Benzol:		
Domestic	288,000	380,000
Imports	70,000	40,000
Alcohol:		
Domestic	170,000	180,000
Total	1,800,000	2,003,000

Hamburg is the leading German port of entry for petroleum and 61 percent of all German oil imports are distributed along the Elba harbors from Hamburg. Of a total of 17 German refineries operating domestic and imported crude, nine refineries with an annual capacity of 1,400,000 tons are situated in the district of Hamburg. Two-thirds of the 52,000 filling stations throughout all Germany are under the control of Hamburg interests. In Hamburg alone there are 750 filling stations.

Between 1914 and 1934 Hamburg has built 208,000 tons tanker capacities (22 units), while 31 units totaling 350,000 tons were built at Kiel. The total for all Germany during this period is 70 units totaling 782,000 tons. In 1900 Hamburg became the oil center of Germany and adjacent countries when the Rhenania Ossag, Standard and Shell established their main offices there.

German oil imports consist of 37 percent

List of German Refineries

Company	Location	Capacity (tons)	
Rhenania Ossag Werke (Shell)	Harburg	300,000	
	Hamburg	150,000	
	Manheim	100,000	
	Reisholz	60,000	
	Harburg Wilhelmburg	60,000	
	Regensburg	15,000	
	Freital	10,000	695,000
I. G. Farben	Leuna & Merseburg		400,000
Ebano Asphalt Werke A.G.	Harburg		360,000
Deutsch Amerkanische Petroleum Ges	[1] Berlin Tempelhof	25,500	
	[1] Dusseldorf	38,500	
	Schulau Wedel	17,500	
	Regensburg	15,000	96,500
Deutsche Erdoel Raffinerie A.G.	[2] Misburg		140,000
Mineraloel Asphalt Werke	Berlin Ostermoor	120,000	
" Benzin Fabrik	Ostermoor	20,000	
	Worthdam Hamburg	20,000	160,000
Deutsche Vacuum Oelwerke A.G.	[2] Oslebenhausen	100,000	
	Shulau Wedel	28,000	128,000
Deutsche Petroleum A.G. Benzinwerke Oelwerke	Berlin	5,000	
	[2] Wilhelmsburg	60,000	65,000
Ernest Schlieman Oelwerke	Hamburg		70,000
Oelwerke Julius Schindler	Hamburg	45,000	
" Mineralwerke	Peine	15,000	60,000
Deutsche Gasolin A.G.	Emmerich	60,000	
	[2] Doelbergen	40,000	100,000
Mineralwerke Albrecht	Hamburg		30,000
Erdoel Raffinerie Salzbergen (Ersag)	[2] Salzbergen		21,000
Westfallische Mineralwerke Schmitz	Dortmund		20,000
Mineraloelwerke Lichtenberg	[2] Berlin		18,500
Mineraloelwerke Vorm. Korff	Bremen		15,000
Zeller & Gmelin	Esslingen		10,000
Pretschner & Wagawa	Naudorf Pirna		10,000
Machinenoel Imprort Ges.	Hamburg		10,000
Max Loeb	Koeln		10,000
Bremer Chemische Fabrik	Klaffenbach		8,000
Deutsche Viscobil A.G.	Berlin		4,000
Koelner Benzin Raffinerie	Braunsfeld Koeln		4,000
Philipp Muehsam	Britz Berlin		1,500

[1] Benzine Fabriken.
[2] Processing Domestic Crude.

gasoline (gasoline, kerosene and gas oil forming 60 percent of the total). Ten percent of the remaining oil imports are lubricating oil and 10 percent fuel oil.

German Oil Imports

(tons)

	1929	1933	1934	1935
Crude	97,900	280,600	276,600	515,000
Gasoline	1,063,400	1,004,700	1,158,400	1,224,000
Kerosene	148,800	97,400	98,200	75,000
Gas Oil	364,700	467,300	639,900	883,000
Lube Oil	657,800	276,300	322,000	437,000
Fuel Oil	.....	310,800	336,200	326,000
Others	380,100	247,500	343,100	365,000
Total	2,712,700	3,684,600	3,154,400	3,825,000

In connection with the accompanying table of German oil imports it is interesting to note that in a recent proclamation emanating from the German Chancellor, full expression is given to the intention of the German government to render the country completely independent of imported refined oil in three or, at most, four years. A large number of oil and chemical plants have recently been constructed in Germany and more plants are contemplated. Refinery experts who have visited Germany recently, although not permitted free access to the chemical plants or oil refineries, have expressed the opinion that the government, following its present system, is entirely capable of achieving this aim if they are willing to make the necessary financial sacrifice.

Geographical Distribution of Refineries in Germany

Location	No. Refineries	Annual Capacity (tons)	Annual Domestic Crude Capacity (tons)
Hamburg District	14	1,500,000	180,000
Bremen	2	150,000	100,000
Rheinland	7	270,000	.....
Hannover	3	166,000	166,000
Thuringia	1	21,000	21,000
Wurtemberg	1	10,000	10,000
Bavaria	2	30,000	.....
Berlin	5	65,000	18,500
Saxonia	3	28,000	.....
Total	38	2,240,000	495,500

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Comparative Cost and Supply of Addition Agents

(Continued from page 479)

lead was based on a charge of 0.35 cents per cubic centimeter plus an average gallonage charge of 0.55 cents per gallon. At present the cost is only 0.26 cents per cubic centimeter of lead with no gallonage charge.

The trend in the price increase as the octane number of the fuel becomes greater is depicted graphically in the accompanying chart which reveals this trend both for motor and aereo fuels. It shows that aereo fuels of 73 octane number are quoted at 10 cents per gallon and the increase to 100 octane number is gradual up to 87 octane but the final price is just double. Mid-Continent motor fuels of 62 octane and below had an average quotation of 4.40 cents per gallon, 64–66 octane averaged 4.58 cents and 68–70 averaged 4.93 cents per gallon in 1935. Premium fuel of 78 octane number is generally quoted 2 cents above 70 octane fuel.

The graph shows that the octane price curve is steeper for motor fuels below 70 than for aereo fuels below 87 octane but from 78 to 100 octane the same trend prevails. The price trend established by the aereo fuel quotations between 73 and 87 if carried out indicates that 100 octane fuel will most likely be around 14 cents per gallon. The price trend of fuels of 70 octane and below if carried out points out that 78 octane fuel eventually will not carry as high a differential at the refinery as prevails today. This may be attained by reducing the lead content through the use of polymer gasoline.

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Increased World Refining Capacity

(Continued from page 486)

the construction of a new plant in the Canary Islands, contract for which was awarded to Bethlehem Steel Co. The plant includes a 4,100-bbl. Dubbs cracking unit.

Importance of the Near East as a refining center has been increased by several developments during the past year. Chief among these was the completion of the extensive program of enlargement at the Abadan refinery of the Anglo-Iranian Oil Company, which makes it the largest refinery in the world.

A particular feature of this plant is the 10,000-bbl. stabilizing unit supplied by Alco Products, which is of special design due to the fact that the crude oil is mixed with natural gasoline at the field and serves as a vehicle for delivering natural gasoline to the refinery. The crude is distilled and an overhead of 10,000 bbl. per day of natural gasoline is obtained. The stabilizer in this case handles not only the naturally occurring gasoline in the crude, but also the additional gasoline distillate separated in the field from other crude oil. This great plant is the subject of a special article elsewhere in this issue.

Equal in interest, though not in size, to the enlargement of Abadan is the new plant of Bahrein Petroleum Co., subsidiary of the California Texas Oil Co., on the Island of Bahrein in the Persian Gulf. Originally designed for a capacity of 10,000 bbl. daily the plant is being enlarged, even before completion of the original project, to double this capacity. It undoubtedly will play an important rôle in the plans of the California Texas Co. for its eastern operations.

Another interesting plant completed during the year was the stabilization unit built for the Iraq Petroleum Co. by Foster Wheeler Ltd. at Kirkuk. Physical difficulties of unusual proportions attended this task since it involved the shipment of 3,000 tons of material by ocean freight through the Mediterranean, via the Red Sea around to Basra and thence 400 miles by rail or else across 700 miles of desert from Haifa. In spite of this handicap and unfavorable weather conditions, the work was completed promptly on time, in June of this year.

The government of Iraq has projected a refinery on its own account for the domestic supply of petroleum products and has engaged an engineer to take charge of the work, but details of the plant have not been completed as yet.

At Digboi, India, the Assam Oil Co. has enlarged its 7,000-bbl. refinery by reconstructing its Dubbs cracking units.

Extensive improvements have been made by the Royal Dutch Company in its refinery at Pladjoe, Dutch East Indies, including the installation of two Dubbs cracking units of 8,500 and 8,000 bbl. daily capacity.

In South Africa the South African Torbanite Co. is building a 1,000-bbl. distillation unit for handling shale oil.

British Imports Continue to Increase

DURING August a further increase occurred in British petroleum imports. Receipts for the first eight months of the current year are 3.4 percent higher than during 1935. A feature of the rise is the increasing importance of the Dutch West Indies as a source of supply. Nearly half the motor spirit arrivals are now coming from the Dutch West Indies, while shipments of crude and products from that source exceed 21,000,000 bbl., an increase of 21.1 percent over the corresponding period of last year. The sharp rise of lubricating oil imports reflects the continued expansion of the British heavy industries.

British Oil Imports by Products
(Bbl.)

	August 1936	8 months to Aug. 31, 1936	8 months to Aug. 31, 1935
Kerosene	442,628	3,778,971	3,288,455
Motor spirit	3,145,885	24,650,400	24,903,088
Lubricating oil	271,257	2,295,257	1,966,485
Gas oil	339,973	2,183,599	1,903,828
Fuel oil	2,488,971	13,213,371	12,976,659
Other sorts	33,115	284,802	307,914
Total products	6,721,829	46,406,400	45,346,429
Crude	1,444,714	10,489,743	9,672,800
Total imports	8,166,543	56,896,143	55,019,229

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British Solvent Refining

(Continued from page 550)

There are also eight steam smothering stations, with wall protection for the men who would operate the valves on the steam lines.

Facilities for process control and research are available in a laboratory comprised of two fire-proofed connected buildings, each 50 ft. x 20 ft., equipped with the very latest testing and research apparatus. An interesting feature of the laboratory equipment is a Duosol pilot plant, in which the full operation of the solvent extraction system may be accomplished in miniature. Similar small-scale units are available also for the study of contact filtration and solvent dewaxing: for the former, a laboratory model of a Sweetland filter is used, while small-scale solvent dewaxing trials are possible at temperatures as low as −30 deg. F. in a specially built "cold-room."

Everything possible has been done at the East Halton Refinery to facilitate the proper organization of services. There is a canteen and messroom to accommodate 250 men and smaller dining rooms for the staff and management. The kitchen is equipped with the most modern apparatus required by an industrial canteen. Washrooms and drying racks for clothes are also provided.

Every precaution has been taken to safeguard the employees by education in the prevention of accidents. Any accidents that occur are treated in a first aid station equipped with all necessary appliances, where men qualified to deal with such emergencies are always in attendance.

There is ample accommodation for motor cars, cycles and motorcycles of the employees, as well as facilities for garaging road tank vehicles.

The need for high grade lubricating oils has steadily increased during the past few years, as changes in engine design have brought about a demand for oil of specialized characteristics to meet the requirements of increased compression ratios, greater bearing pressure, advanced speeds and higher temperatures. To satisfy this need was the particular purpose of Herbert Green & Co. Ltd. in constructing their East Halton refinery which is now producing a range of finished lubricants of a quality not heretofore manufactured in Great Britain.

Comparison with lubricating oils manufactured by methods in common practice to-day shows that lubricants produced by the Duosol refining and Double Solvent dewaxing processes have a lower specific gravity for a given viscosity and less change in viscosity with variation in temperature. They have a higher flash point in relation to viscosity and there is thus a lower consumption. Being wax free, they can be used with equal success in extreme cold or under extreme heat. They are free from acid sludge and so insure smooth operation and economy in power, oil and fuel consumption.

The Duosol solvent refined and Double Solvent dewaxed oils produced at East Halton have been subjected to the severest possible tests to substantiate the claims made for them and oil technicians are agreed that they achieve an enviable high standard of perfection in operation. Such oils are marketed at competitive prices, and, by reason of their extraordinary resistance to the effects of both heat and cold, cover a far wider range of operating conditions than other lubricants. Fewer grades of motor oils therefore are necessary to satisfy the requirements of automotive units.

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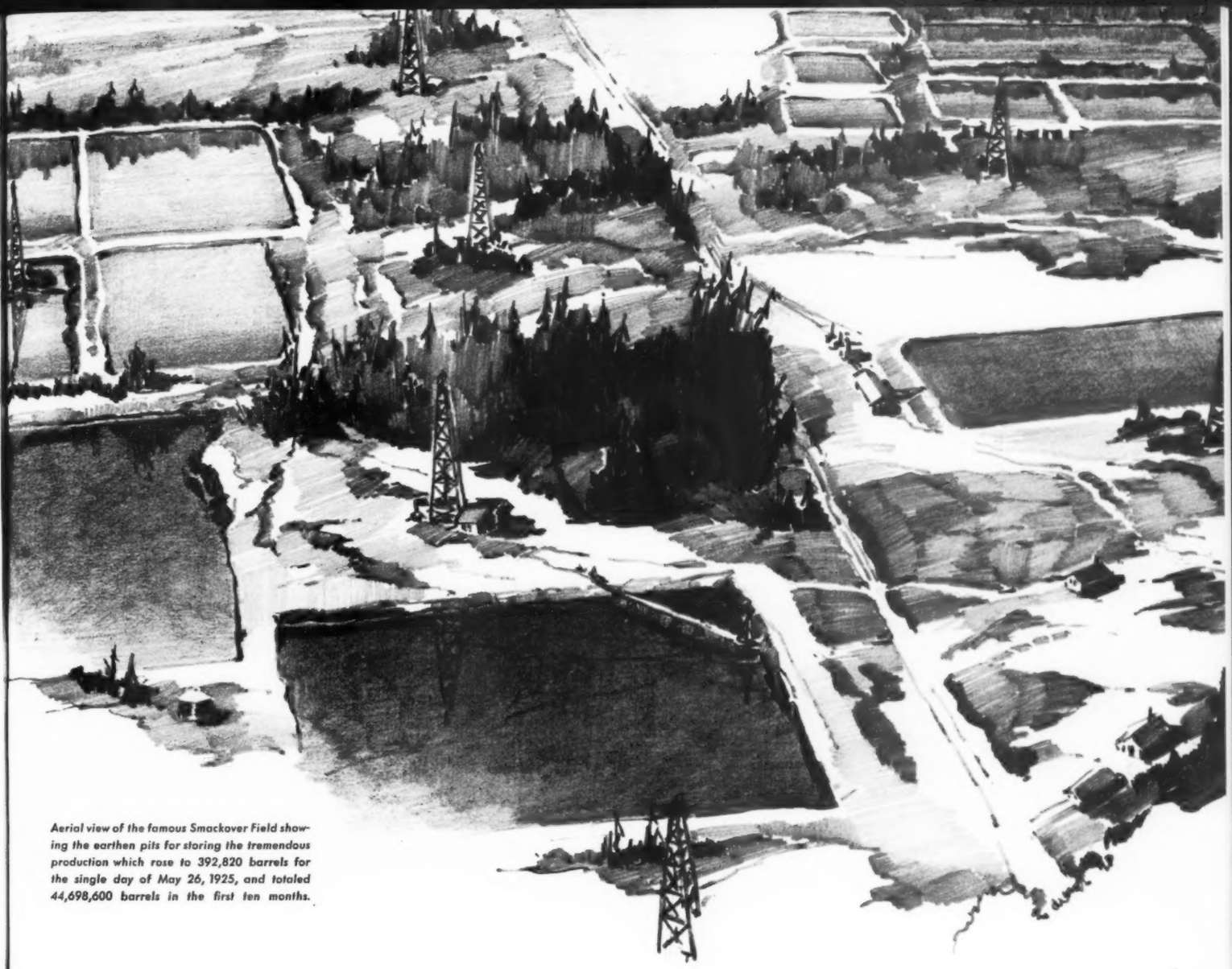
Gulf Export Prices for Major Oil Products

Products		Cents per Gallon			
		Aug. 4	Aug. 18	Sept. 2	Sept. 16
Gasoline:	U. S. Motor	5¼	5¼	5¼	5¼
	64/66-375 E.P.	5½	5½	5½	5½
	59 Octane & below	5½	5½	5½	5½
	65 Octane & above	6⅛	6⅛	6⅛	6
Aviation Gasoline: (Tank-car F.O.B. Ref.)	73 Octane & above	10	10	10	10
Kerosene:	44 w.w.	4⅛	4⅛	4⅛	4⅛
	41-43 w.w.	3⅝	3⅝	3⅝	3⅝
	41-43 p.w.	3⅝	3⅝	3⅝	3⅝
Gas Oil:	26-30 translucent	3⅛	3⅛	3⅛	3⅛
	30 plus translucent	3⅛	3⅛	3⅛	3⅛
Fuel Oil:	Grade C Bunker (per bbl.)	.90	.90	—	—
	Cargo lots (per bbl.)	.85	.85	—	—
	Diesel oil (per bbl.)	$1.50	$1.50	—	—
Lubricating Oil: (New York Export Market)	Bright Stock No. 8	28	27½	28	28
	Bright Stock No. 6½	27½	27	27½	27½
	Warren E.	22½	22½	22½	22½
	600 Unfiltered	20½	20	20	20
	650 Unfiltered	21½	21½	21½	21½
	600 Flash s.r.	22½	22½	22½	22½
	650 Flash s.r.	24½	24½	24½	24½
	Neutral 200 No. 3	27½	27½	27½	27½
	Neutral 150 No. 3½	24	24	24	24
So. Texas:	Red oil 500 No. 5-6	7¼	7¼	7¼	7¼
	750	9	9	9	9
	1200	9¼	9¼	9¼	9¼
	Pale oil 500	7⅞	7⅞	7⅞	7⅞
	750	9	9	9	9
	1200	9¼	9¼	9¼	9¼
Crude Oil:	East Texas crude delivered at Gulf port for Export (per bbl.)	$1.35	$1.33	$1.33	$1.32
	Venezuela (per bbl.)	—	—	—	—
	Trinidad crude (per bbl.)	.85	.85	.85	.85
	Panuco crude (per bbl.)	—	.95	.95	.95

Freight Rates

	Aug. 4		Aug. 18		Sept. 2		Sept. 16	
	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean
(Shillings per ton)								
Calif.—U. K. or Continent	20/-	21/-	20/-	21/-	18/-	19/-	20/-	18/-
Gulf—U. K. or Continent	10/-	11/-	9/3	9/5	9/6	11/6	9/9	11/6
(Cents per barrel)								
Calif.—North Atlantic	55	55	42	42	42	55	42	55
Gulf—North Atlantic	15	17	14	15	15	17½	18	20
Venezuela—North Atlantic	15	—	15	—	15	—	15½	—
Tampico—North Atlantic	16	—	16	—	16	—	16	—



Aerial view of the famous Smackover Field showing the earthen pits for storing the tremendous production which rose to 392,820 barrels for the single day of May 26, 1925, and totaled 44,698,600 barrels in the first ten months.

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OIL AND GAS WELL CHEMICAL SERVICE

World Oil Production—Official Figures for 1935 and 1936 Revised

All figures furnished direct to WORLD PETROLEUM by Governments, except where otherwise specified

(Figures in U. S. Barrels—Conversion ratio 7 bbl. = 1 ton)

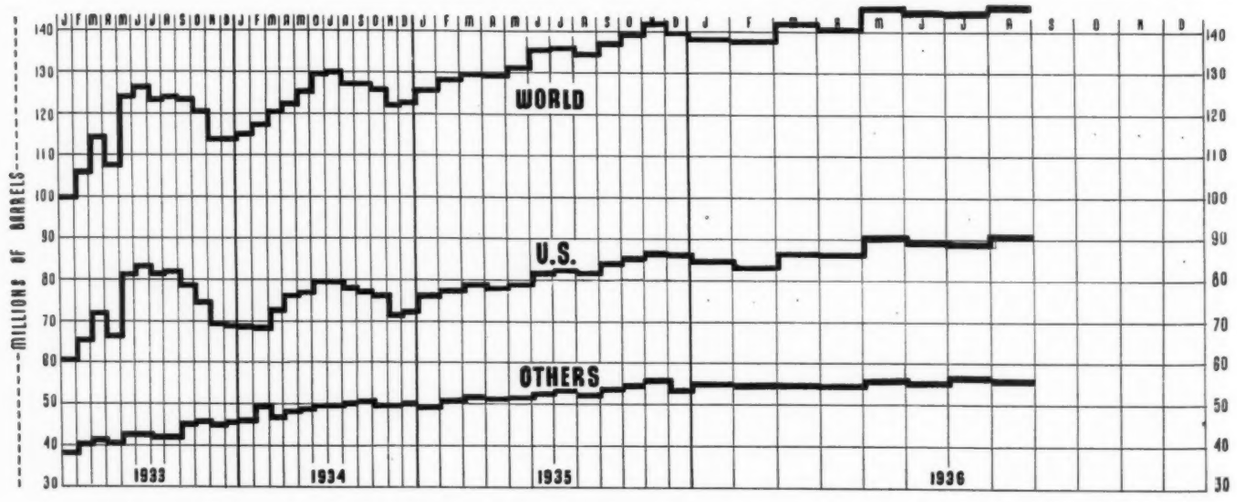
Country	September 1935	October 1935	November 1935	December 1935	January 1936	February 1936	March 1936	April 1936	May 1936	June 1936	July 1936	Provisional Figures August 1936
United States	84,109,000	88,160,000	86,475,000	88,711,000	88,820,000	82,120,000	90,568,000	90,479,000	93,739,000	90,185,000	92,078,000	95,090,000
Russia	14,849,100	16,040,500	16,050,000	16,100,000	16,155,300	15,288,700	16,344,300	15,589,000	16,454,200	15,955,100	15,680,000[1]	15,600,000
Venezuela	13,151,362	13,681,619	13,152,766	13,389,789	13,487,089	12,849,480	13,432,671	13,442,870	13,722,933	12,486,600	14,566,510	14,632,737
Roumania	4,932,000	5,181,000	5,215,000	5,361,000	5,242,000	4,809,000	5,209,000	5,226,000	5,568,000	5,563,000	5,606,000	5,585,000
Iran[2]	4,270,000	4,109,000	4,522,000	4,816,000	4,627,000	4,480,000	4,641,000	4,312,000	5,376,000	5,061,000	4,872,000	4,839,689
Netherland India	3,661,259	3,767,596	3,528,889	3,612,056	3,614,436	3,407,194	3,670,877	3,532,375	3,721,613	3,549,417	3,725,491	3,715,887
Mexico	3,442,259	3,461,457	3,340,713	3,666,265	3,377,302	3,285,965	3,542,088	2,997,883	3,235,255	3,167,300	3,179,614	3,773,503
Iraq	1,962,541	2,374,393	2,309,867	2,240,819	2,327,332	2,107,210	2,515,345	2,048,053	2,467,136	[2]3,473,660	2,440,669	2,479,428
Colombia[3]	1,555,676	1,623,372	1,582,952	1,004,474	1,611,618	1,475,403	1,619,620	1,427,193	1,598,544	1,529,901	1,585,345	1,578,768
Peru[4]	1,448,133	1,493,236	1,343,848	1,381,031	1,377,006	1,293,627	1,351,810	1,403,626	1,500,485	1,452,306	1,524,303	1,527,072
Argentina	1,152,919	1,200,698	1,193,434	1,304,554	1,310,129	1,273,243	1,366,691	1,260,277	1,231,354	1,257,390[1]	1,313,004[1]	1,312,199
Trinidad	992,445	1,015,492	1,078,957	1,086,530	1,079,082	983,424	1,081,191	1,026,423	1,066,728	1,078,186	1,121,583	1,108,969
British India	775,133	790,612	649,041	841,764	854,644	756,384	791,162	790,376	827,762	778,947	799,924[1]	799,924
Poland	301,000	308,000	294,000	308,000	338,800	323,400	338,800	323,400	331,100	287,000	294,000	301,000
Brunei	256,480	233,310	242,900	274,540	253,400	237,930	257,250	270,900	225,890	206,780	266,700	275,310
Germany	229,712	232,659	236,789	263,879	254,492	227,444	274,393	246,519	244,552	256,613	272,699	257,859
Japan	144,312	158,165	145,749	147,827	183,651	165,877	196,569	194,167	203,071	198,387	206,284	221,139
Sarawak	145,600	148,400	141,400	140,700	139,300	127,050	136,290	130,900	134,610	128,660	130,200	129,150
Ecuador	138,986	147,449	143,518	146,541	148,980	138,721	162,125	159,666	163,855	156,703	163,714	160,914
Canada[5]	123,919	122,525	116,756	125,658	121,231	107,928	117,824	107,748	114,297	114,050	139,940	139,789
Egypt	100,954	103,341	96,495	94,969	91,497	97,373	111,846	101,038	107,989	106,694	106,260	102,620
France[1]	43,530	44,981	43,530	44,981	44,981	42,079	44,981	43,530	44,981	43,530	44,981	45,000
Bahrein[1]	105,400	105,400	105,400	105,400	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Others[1]	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Total	137,966,720	144,578,205	142,084,014	145,242,777	145,834,270	135,972,632	148,148,833	145,487,944	152,454,355	146,411,224	150,496,221	154,050,957

[1] Estimate. [2] Anglo-Iranian Oil Co. figures revised; fuel oil returned to the ground has been deducted. [3] International Petroleum Company's figures. [4] International Petroleum Company and Lobitos Oilfields Ltd. figures. [5] Includes natural gas production.

Russian Sakhalin included with Russia. Japanese Sakhalin included with Japan.

Official Crude Oil Production Figures for 1932 to 1936

	Total 1936	Daily Average 1936	Total 1935	Daily Average 1935	Total 1934	Daily Average 1934	Total 1933	Daily Average 1933	Total 1932	Daily Average 1932
United States	721,905,050	2,958,627	993,942,000	2,723,129	909,107,000	2,490,704	898,874,000	2,462,670	785,159,000	2,145,243
Russia	127,066,600	520,765	176,688,100	469,608	168,648,700	462,051	149,901,900	407,950	149,719,000	409,070
Venezuela	108,620,890	445,168	153,932,611	421,733	140,784,805	385,712	120,882,802	331,186	119,596,512	326,766
Roumania	42,808,000	175,443	61,150,000	167,534	62,006,000	169,879	50,971,200	139,647	50,491,205	137,954
Iran	38,208,689	156,593	52,413,879	143,600	52,663,782	144,284	48,581,280	135,840	45,122,455	123,285
Netherland India	28,937,290	118,595	42,569,625	116,629	42,289,408	115,861	38,512,663	105,516	39,584,027	108,153
Mexico	26,558,910	108,848	40,234,902	110,233	38,167,022	104,567	33,904,882	92,890	32,802,285	89,624
Iraq	18,858,833	77,290	24,850,924	68,085	7,935,657	21,742	1,200,000	3,288	1,200,000	3,300
Colombia	12,426,392	50,928	17,617,654	48,740	17,340,724	47,509	13,157,127	36,047	16,834,956	44,768
Peru	11,430,235	46,845	16,835,206	46,270	15,936,937	43,663	13,923,281	38,146	9,899,266	26,026
Argentina	10,328,287	42,329	14,317,500	39,226	14,045,652	39,015	13,759,565	38,232	13,166,900	35,975
Trinidad	8,545,586	35,023	11,669,792	31,686	10,894,363	29,847	9,560,039	26,192	10,023,780	27,387
British India	6,399,123	26,226	9,227,496	25,281	8,997,399	24,650	8,721,655	23,893	8,600,312	23,500
Poland	2,537,500	10,400	3,973,200	10,885	3,697,617	10,130	3,858,085	10,570	3,905,230	10,670
Brunei	1,994,160	8,173	3,162,614	8,647	2,673,041	7,323				
Germany	2,034,571	8,338	3,054,023	8,409	2,266,964	6,211	1,712,823	4,692	1,824,019	4,983
Japan	1,556,220	6,378	1,848,656	5,065	1,484,962	4,068	1,337,761	3,827	1,575,333	4,375
Sarawak	1,056,160	4,329	1,811,297	5,002	1,948,044	5,337	2,289,472	6,273	2,274,043	6,213
Ecuador	1,254,678	5,142	1,725,354	4,727	1,655,062	4,534	1,622,624	4,446	1,573,857	4,300
Canada	937,908	3,844	1,434,467	3,933	1,418,810	3,887	1,147,825	3,144	1,054,373	2,880
Egypt	825,517	3,383	1,215,606	3,356	1,479,037	4,052	1,591,495	4,360	1,742,370	4,760
France	354,063	1,451	529,664	1,451	552,000	1,512	552,000	1,515	552,000	1,508
Bahrein	2,400,000	9,836	1,264,809	3,465	285,071	781				
Others	600,000	2,459	900,000	2,470	861,000	2,359	432,000	1,184	432,000	1,180
	1,177,644,662	4,826,413	1,636,369,379	4,470,161	1,507,139,037	4,129,678	1,417,534,479	3,884,022	1,296,682,923	3,544,940



World crude oil production by months, 1933–1936. Chart is weighted to compensate for variation in number of days per month. Ratio of U. S. crude production to world production.

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Official Figures for Soviet Oil Operations

	Crude Production (bbl.)	Daily Average (bbl.)	Runs to Stills (bbl.)	Drilling (feet)
1936				
January	16,155,300	521,139	13,993,000	509,950
February	15,288,700	526,955	13,055,700	516,140
March	16,344,300	527,235	14,259,700	610,306
April	15,589,000	519,633	13,418,300	619,420
May	16,454,200	530,781	14,356,300	621,911
June	15,955,100	531,837	14,365,400	510,860
July	15,680,000	506,000	14,100,000	560,000
August	15,600,000	503,230	14,150,000	550,000
Total 8 months 1936	127,066,600	520,765	111,698,400	4,498,597
Total 8 months 1935	112,020,200	479,591	95,469,400	3,159,836
Total 1935	176,688,100	497,713	146,705,100	4,868,465
Quota 1935	212,310,000	580,082	171,500,000	5,214,000
Quota 1936	213,500,000	584,931	175,000,000	7,100,000

Crude conversion: seven bbl.=one ton.

NO CHANGES were reported in Soviet oil operations during the month of August. Crude production has become stabilized since June with plan fulfillment slightly above 90 percent of the quota on the average. From the accompanying table it is to be seen that the major portion of crude still is being derived mainly from Baku, which fields together with Grozni and Maikop supply about 91 percent of the total for all Soviet fields. Among fields outside of the Caucasus, Bashkiria is gradually gaining in importance, followed by Emba, Turcomania, Sakhalin, Middleasia and Kamaneft.

Soviet Crude Production by Fields
Jan.–Aug., 1936

	Total (bbl.)	Daily Average (bbl.)	Percent of Total
Baku	95,600,000	392,100	75
Grozni	15,850,000	65,000	12
Maikop	5,150,000	21,100	4
Total Caucasus	116,600,000	478,200	91
Total Outside Caucasus	10,466,600	42,566	9

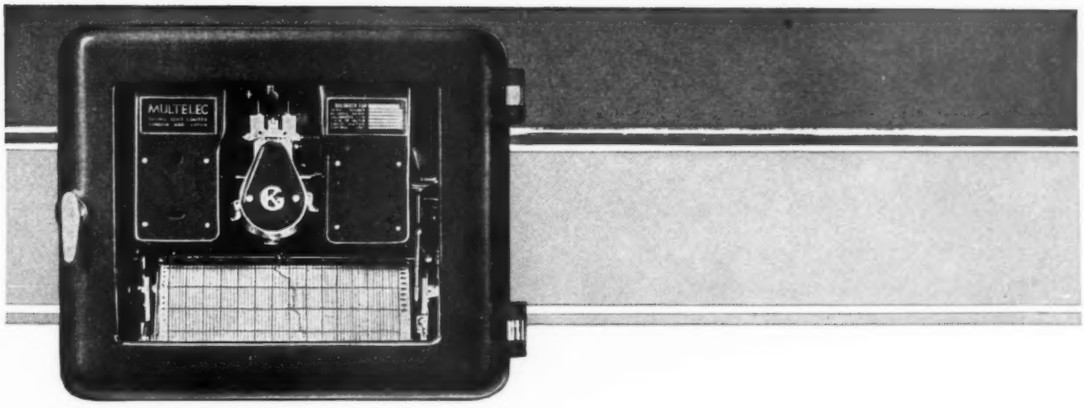
The ratio to the total of all fields supplied by the fields outside the Caucasus is as follows: Bashkiria, three percent; Emba, Sakhalin and Turcomania, 1½ percent each; Middleasia, one percent; and Kama, one half of one percent. The fields outside the Caucasus are slowly but surely making progress, as shown by the fact that crude production from these fields has grown from 4.5–5 percent in past years to 9 percent at present.

Of all the Baku oil field groups only the Lenin field has been able to live up to plan in crude production (on individual days exceeding the plan from two to three percent). All other Baku groups have operated between 80 and 95 percent, thus making a total for all Baku of 91.5–92 percent of the plan for the month. Other Soviet fields operated during the month as follows: Grozni, 80–90 percent; Maikop, 70–82; Bashkiria, 90–99; Emba, 50–55; Turcomania, 51–60; Middleasia, 72–79; and Sakhalin, 105–121 percent of the plan.

Steady progress is being reported in Soviet drilling and the speed per table per month is consistently approaching American field practice. Wells of 3,500 ft. are now being drilled and completed in six or seven days, instead of 12 to 14 months as in former years. However, outside of speed of drilling, many operations of this division are still fraught with difficulties, the overcoming of which will require time and practice.

ZA INDUSTRIALIZATIU of August 17th states that M. Barinov's report on all he has seen and inspected while on a visit to the United States will undoubtedly have a significant bearing on Soviet oil operations in the nearest future. It looks as if a new chapter will be written in the history of Soviet oil and S. Ordzonikidze, Commissar for Soviet Heavy Industries, is correct in stating that the now pending reconstruction of Soviet oil will not only be of importance to the oil industry but to the entire Soviet economy. Modern, efficient methods are to be introduced and equipment will be utilized to better advantage than heretofore, and, under Stakhanov operation, the oil industry must serve as a model to all other Soviet industries.

M. Barinov, the paper continues, has vividly described how American oil operators simplify operations by making use of every possible means of production at hand. With a high degree of efficiency, which is visible in all U.S.A. oil field operations, the operator does not delay



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field development until the field is electrified. When oil is struck steam boilers are immediately installed and drilling begins. No time is lost in erecting super structures or complicated installations, as opposed to Soviet drillers who prefer to hold up operations until the field is electrified. The paper asks bluntly whether this is super-industrialization or stupidity? S. Ganshin, head of Bashkiria, has reported that everything necessary to start new drilling is available in the field, but that he preferred to put off operations until electricity would be available. He does not deny the fact that sufficient gas was available in the fields to supply all the power necessary, but claims it would have been out-of-date to drill without electrical power.

M. Barinov and his commission have made a thorough study of American oil field practice and they do not in any way advocate a return to steam, but they emphatically favor making the fullest use of steam when electricity is not as yet available. Barinov also related that U.S.A. field operators do not hold up drilling or general development until roads are built or permanent housing erected. Any means of communication is utilized in the U.S.A.; temporary shacks are erected instead of houses and light motor cars and trucks make the wheels rotate. No machine repair shops are necessary; instead they arrange for sufficient supplies to reach the fields uninterrupted. American field operators do not discard used machinery and equipment, it being overhauled, repaired or remodelled in line with requirements and brought again to the fields. While American oil operators are alert and experiment with all sorts of new innovations, they make the fullest use of rebuilt and remodelled machinery and equipment.

The paper asks whether it is worth while to learn from America and whether Soviet operators are in a position to learn. The answer is decidedly in the affirmative. Soviet crude production must be increased, as must prospecting, drilling and refining, but all this has to be done in more practical ways in the future.

AFTER the return of M. Barinov and his commission from their four months' visit to the United States, a conference was called by the Commissar for Soviet Heavy Industries, S. Ordzonikidze, at Moscow in the middle of August to hear the reports of the commission. The conference was headed by Ordzonikidze and assisted by Rukhimovitch, vice-Commissar, and about 150 representatives of Soviet oil were present. The main speeches were delivered by M. Barinov, head of Glavneft; V. Poliakov, head engineer of Glavneft; Krems, head geologist of Glavneft; and others.

The interesting feature of the conference was the complete absence of any display in regard to the victories attained on the front of oil. With the exception of a few references to individual conservatism, nobody in particular was blamed for the retarded progress and nobody was praised exuberantly, nor was reference made to the glory of the Party and its leader, J. Stalin. Evidently this was a purely business conference and it looks as if the Soviet oil industry is going to do business in the form

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Refinery acid sludges of grades that can not be separated or utilized by former processes may be satisfactorily converted into high quality acid and useful by-product by this CHEMICO process.

The recovered acid is *clean* because the gas from which it is made is free of carbonaceous and other solid material. It can be strong as desired because ability to produce 98% and fuming acids is a characteristic of the contact acid process and the sulphur content of the sludge is not the governing factor. The acid required to make up treating losses may be cheaply produced in the same plant from hydrogen sulphide recovered from still gases or from sulphur.

The regeneration of sulphuric acid by this CHEMICO Process has everything in its favor:

1. The strength and purity of the recovered acid are equal to those of fresh purchased acid.
2. The plant construction, operating and depreciation costs are low for these reasons: (a) Compact equipment minimizes the ground area and building volume required, (b) the vanadium catalyst used in the contact acid converter is extremely durable and non-poisonable by chemical impurities that ruin platinum, (c) generally there is no fuel expense, as the quantity of by-product coke produced greatly exceeds that required for heat treatment of the sludge, (d) centralized plant control brings operating labor requirements to a minimum, (e) an overall yield of 90% of the acid contained in the sludge is regularly obtained in commercial operations.
3. Sludge disposal and atmospheric pollution problems are wholly eliminated as there is no waste residue, and the equipment is sealed throughout against the escape of objectionable fumes. The elimination of labor required for non-productive sludge disposal effects a definite money saving, and further intangible but very real economy results from avoiding the pollution that with ordinary disposal creates controversies with public officials.

The first commercial plant, installed in 1932, is operating regularly at higher than its designed capacity of 50 tons of fuming acid per day with highly profitable results to its owners. Another installation is now under construction abroad for a prominent oil refining company.

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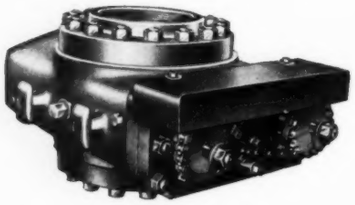

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of a cardinal reconstruction along the lines of American practice.

Following are the highlights of some of the important speeches as they were quoted by ZA INDUSTRIALIZATIU of August 17th, 1936:

M. Barinov quoted past history of Soviet oil since nationalization. During the period between 1920 and 1927 a total of 49,300,000 tons of crude were produced and 3,650,000 ft. of drilling was accomplished at a speed of 188 ft. per table per month. During the First Piatiletka the corresponding figures were 91,700,000 tons of crude and about 10,000,000 ft. of drilling at 300 ft. of drilling speed. The years of the Second Piatiletka brought:—

1933..21,500,000 tons of crude; 2,650,000 ft. drilling at 378 ft. speed.

1934..24,200,000 tons of crude; 4,300,000 ft. drilling at 630 ft. speed.

1935..25,250,000 tons of crude; 4,950,000 ft. drilling at 785 ft. speed.

Soviet Oil Exports, Jan.—June, 1936

(tons)

	6 months 1936	6 months 1935
Crude Oil	178	9,516
Gasoline	229,963	365,683
Kerosene	199,578	213,562
Lube Oil	145,841	118,203
Fuel Oil	483,716	631,674
Diesel Oil	38,958	47,747
Gas Oil	251,749	236,789
Others	5,504	10,584
Total	1,355,637	1,633,758

By Countries

France	227,950	176,730
England	160,339	162,405
Germany	112,008	217,114
Sweden	73,120	78,148
Belgium-Luxemburg	71,800	53,474
Denmark	50,526	61,555
Italy	48,898	129,696
Spain	37,583	116,045
All Others	573,413	638,591
Value in Gold Rbl.*	17,580,000	19,980,000

* 1 Gold Rbl. = 87 cents.

The speed of drilling has further increased during the first quarter of 1936 to 1,190 ft. and during the second quarter to 1,450 ft. Progress is evident, but still insufficient when compared with U.S.A. practice and records. Between 1920 and 1927, American fields have produced 724,000,000 tons of crude and drilled 670,000,000 ft. at a speed of 1,320 ft. Between 1933 and 1935, inclusive, U.S.A. production amounted to 123–140,000,000 tons of crude and drilled between 36–60,000,000 ft. at an average speed of 2,650 ft. Between 50 and 60 new oil regions are discovered in the U.S.A. each year. The Soviet oil industry has discovered about 30 new oil regions during the past 15 years, produces less, drills less and the speed of drilling is practically one-half of U.S.A. showings.

It is true that much has been done in the Soviet oil industry since 1923. A complete reorganization was undertaken in drilling, production and refining. Production, however, has become stabilized and the requirements have grown so immensely that a new reconstruction has become necessary, or rather one would say a revolutionary change must be undertaken to modernize the industry similar to changes made in 1928, and perhaps on a larger scale. (See Mr. Barinov's impressions of U.S. oil industry published elsewhere in this issue.—ED.) U.S. oil operators work fast, develop fast and build and erect necessities required for immediate production of new fields. No power stations are erected, no repair shops and even no roads built. They simply ship sufficient drilling outfits and tackle with spare parts and a group of steam boilers and the wheels begin to rotate. All these can be easily transported to some other place whenever required. Soviet operators spend much time and money for complex erections, a power station, and housing for labor before drilling begins. Is steam suitable for Soviet oil field operation? Decidedly so. We have gas available in all Soviet fields and steam as source of power is not at all inferior to electricity. Soviet operators are reluctant to start drilling without automatic well equipment. All I have to say is that I saw little automatic equipment in average American fields. We have seen thousands of wells in U.S.A. fields operating on steam from boilers installed on wooden supports or even without such; we have likewise seen thousands of wells operated by Ford motors and wonder if this could not be done in Soviet oil fields. We needed costly machine and repair shops in the fields so long as we were short of the supply of spare parts, but can't we do away with these shops now? Our spare parts of the domestic shops are of low quality. Boretz plant, of Grozni, manufactures hundreds of compressors and parts which in appearance are not inferior to similar American make, but their operation is not satisfactory and the details of the spare parts are of low quality. Spare parts are all inexpensive items, but when it is necessary to make them in local repair shops they require special at-

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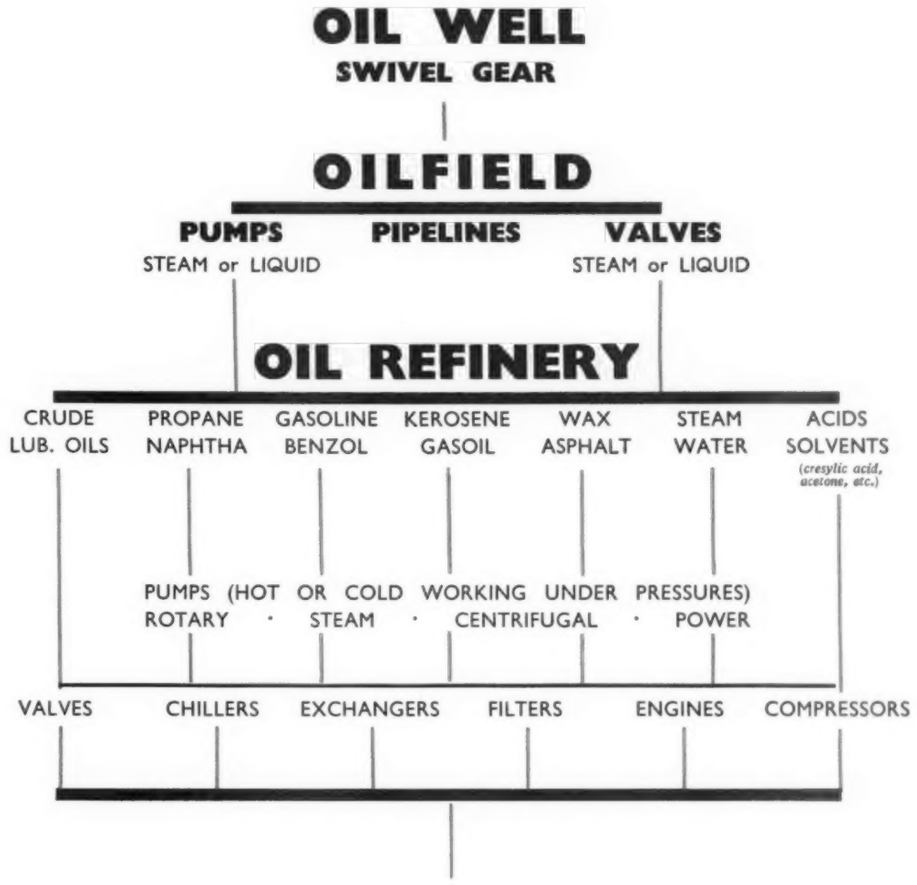

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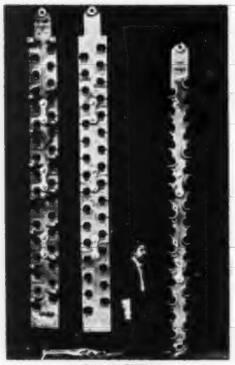

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tention and cost us thousands of Rbl. Such plants as Red Hammer, Shmidt plant, and many others are well adjusted and equipped for the output of oil equipment not inferior to American products, but Soviet finish is bad and, consequently, the operation of the equipment unsatisfactory.

A multitude of auxiliaries in Soviet oil operations make deep cuts in the operating budgets, while U.S.A. operators make all operations so simple. In the U. S. only at drilling depths of over 2,000–3,000 ft. are more stable and elaborate preparations made; otherwise everything is light and portable, while Soviet drilling requires considerable outlays for huge erections even at shallow depths.

While building a bridge over the Uil river for the Emba railroad we lost over a year during which we should have been transporting oil. The river Uil is quite shallow except for two weeks during the year when it is flooded over. In the United States they undoubtedly would have constructed some sort of provisionary pontoon with rails to be used all year and would have stopped operation during the period of overflow, thus saving valuable time which we lost. We must understand once and for all that American technique is highly advanced and that we have a long way yet to go before we can reach a comparable stage. Our success will be assured if we will learn from America.

V. Poliakov told the conference in plain words that when he saw American operators at work he began to understand what efficient oil operation really means—340,000 oil wells scattered over 2,000 different oil regions, with large numbers of wells drilled to shallow depths yielding much below medium production but nevertheless providing the backbone of steadiness and reliability of the U.S. crude output. However, at larger fields with flush production, much gas is being wasted by escaping into the open or burning away, but American operators are alert and quick in the mastering of new oil properties. Geological and geophysical research is of a high standard and prospecting, in general, is much more successful than in the U.S.S.R. American operators are ready to experiment, but they quickly discard what they consider useless. "Djat" pumps, of which so much has been said in the U.S.S.R., were discarded as a failure some three years ago in the U.S. Max and Flow pumps, so much praised in U.S.S.R., never had more than 30 installations in U.S.—and these were soon abandoned. Kobe pumps met a similar reception, now operating at only three wells in the United States, out of a total of 360,000. All Oklahoma City region wells are under deep pump operation under fine hoists of 15 tons capacity. Pumps are elongated and of the 4-valve type. We have heard of this type, but failed to apply it, again losing time.

Americans use United and Portable hoists and overhaul or remodel all used machinery. Some of the remodeled equipment looks brand new, and then one finds that it has been in use for over 10 years. They put hoists on frames thus making them portable, while Soviet operators lose much time in mounting and dismantling hoists for transportation to new

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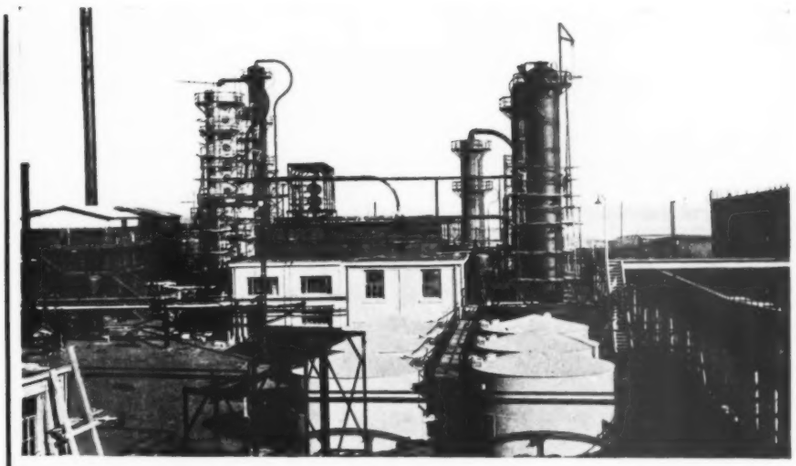

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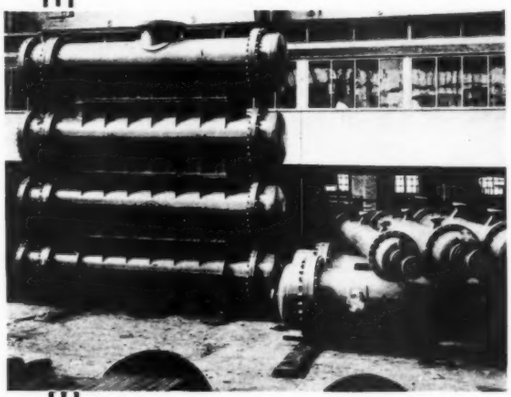

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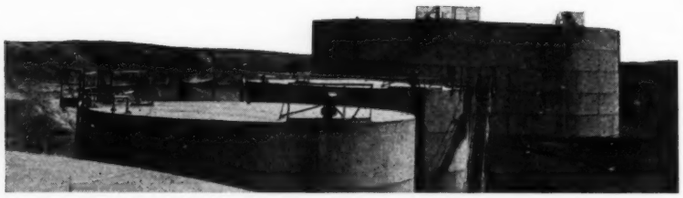

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rigs. Mr. Poliakov spoke further about all sorts of American equipment, and finally came to the conclusion that the Soviet oil industry would have made great progress if operated along American lines of practice and efficiency, using practical sense as Americans do.

S. Ordzonikidze, head of Soviet Heavy Industries, concluded the conference with a brief speech commenting on the reports of Kornienkov and Krems (both geologists of Glavneft) in which they stated that American operators are not reluctant to operate wells which yield as low as 50 kilograms of oil per day. Mr. Ordzonikidze also called attention to the report of Samostrelov (a drilling expert of Ishimbayevo) who spoke of bits drilling 2,000 ft. per table month, while under similar conditions in U.S.S.R. the speed is much lower. Why? Soviet operators hunt for gushers, Soviet bits are of low quality, the material poor and the finish below requirements. U.S.A. operators make extensive use of gas as power, while 30 wells of Ishimbayevo were idle awaiting electricity for operation at a time when all gas available was being wasted. A Ford motor could have done the trick, but no motors were available simply because nobody has thought to ask for such a motor. But S. Ganshin has reported that everything is well at Ishimbayevo except for equipment, power, supplies and high-quality drilling bits.

What the Soviet oil industry needs at present, S. Ordzonikidze continued, is creative initiative, together with daring innovations and a throwing-off of the conservatism and inertness so prevalent under the spirit of Bolsheviki self-criticism, in order to attain fully the Stakhanov tempo of operations. A new epoch is awaiting Soviet oil. Vast, new oil lands are ready to be prospected and opened for operation under entirely modern and progressive methods, resulting in the attainment of maximum results from the objective possibilities at hand.

New Construction

Maikop: A new 6-inch pipeline, 25 kilometers (15½ miles) long was laid over mountains and through forests to connect the Khadizi with the Kutais properties of Maikop. At Kutais, just as at Asphalt mountain which is about 7 kilometers (4 miles) from Khadizi, several wells had been opened with gusher production up to 1,400 bbl. per day, but lacking transport facilities these had to be shut-in. The new pipeline will now open the flow of oil from these wells.

Ufa: The Ishimbayevo refinery has been completed. The daily refinery output will be 1,000 tons of gasoline and 250 tons of ligroin. During September the full capacity of 3,500,000 bbl. of crude will come on stream.

J. WEGRIN